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LIVING SPECIMENS
in the
SCHOOL LABORATORY

Directions for the care and maintenance of the more commonly studied laboratory animals

Second Edition

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INTRODUCTION

The most noteworthy trend in biology teaching during the past ten years has been the greatly increased use of *living* specimens. Teachers are using more and a far greater variety of living plants and animals than was formerly the case; largely, of course, because this is becoming generally recognized as very effective teaching, and also because living specimens are now readily available to all schools, quite regardless of season or geographical location.

During recent years the General Biological Supply House has issued a large number of free service leaflets and informational bulletins, many of which deal with the care of living specimens. Hundreds of thousands of these leaflets have been used in schools and the helpful suggestions of countless teachers have enabled us to revise and improve our leaflets at frequent intervals. The more essential information from many of our leaflets and much new information is now offered in this booklet. The text of *Living Specimens in the School Laboratory* and most of the illustrations have been prepared by the various members of the Turtox scientific staff.

We have attempted to present essential information as briefly as possible, and the discussions are limited to those forms commonly studied in school laboratories. The methods suggested may not be the best in every instance; they are merely the methods which we have found to be most practical in our own and in various school laboratories. In cases where a choice of several methods was possible, we have suggested the procedure requiring the least special equipment, bearing in mind the fact that the average small school laboratory is not elaborately equipped for the care of living specimens.

Teachers desiring information on the care of plant and animal specimens not discussed in this booklet are invited to write to us. We have available for free distribution many helpful informational bulletins, and the Turtox Service Department is at all times ready and willing to answer special inquiries.

Teachers and students are also invited to write to us concerning corrections and additions, and we count upon such help to assist us in improving the next edition of this booklet.

PROTOZOA

Living protozoa offer a fascinating field of study and biological adventure to beginning, as well as advanced, students. Protozoa are almost infinite in form, in habit and in their distribution, and a wide range of very interesting kinds can be found in any random hay infusion or culture of decaying pond weeds. Because such "mixed cultures" contain a great many forms which are not easily recognized is no argument for ignoring them in the school laboratory. Their variety and the changes in the protozoan population which occur from day to day, the cycles through which a mixed culture passes and the great number of different forms present, are all extremely interesting to one who wishes to know something of the science of biology.

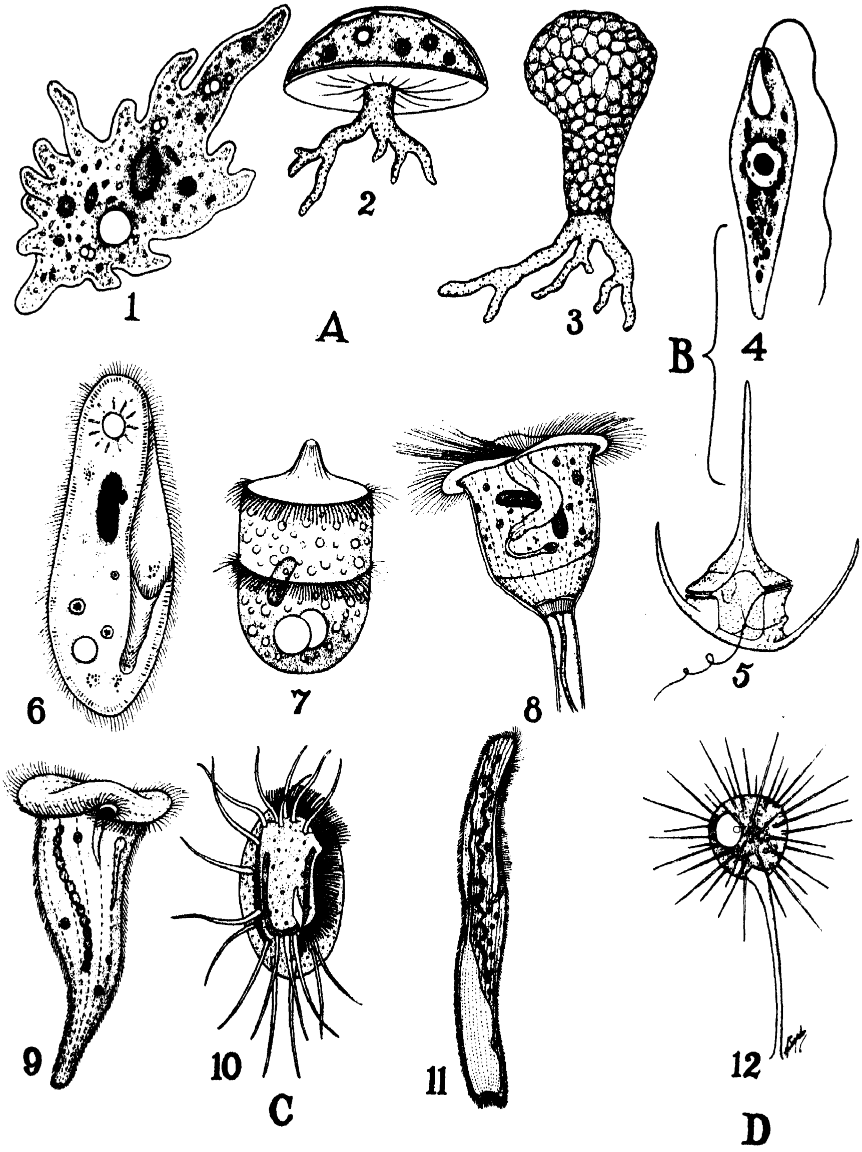
Field collecting in any marsh, bog, pond and stream will produce an abundance of protozoa. Pond collections should consist of water plants, algae, decaying vegetation and some ooze from bottom and water from each situation. Changing water is harmful to many protozoa. The mixed culture does not retain much of its varied protozoan life for a long period because many species go through a cycle and gradually disappear. One species may be in abundance today and tomorrow only scattered individuals remain. Water conditions change quickly in a mixed culture killing off many forms and in a week's time only one or two species will be found in abundance. From good mixed cultures pure cultures may be obtained if the isolation of various species is done as soon as possible. The majority of species may be isolated with a capillary pipette and transferred directly to prepared culture media (as suggested specifically for each species in the following pages). But transferring directly to finger bowls or larger culture dishes makes it difficult to check cultures because of the large amount of liquid. An in-between step may be followed to eliminate some of this trouble. From the mixed culture the various species to be cultured may be transferred to watch glasses which have been prepared with boiled pond water or distilled water, 2 or 3 pieces of boiled timothy and a kernel of boiled wheat. These small watch glass cultures are easily checked under the dissecting microscope and a much closer check can be made as to the progress of the protozoan and contamination. This procedure requires time but is worth the extra precaution when positive results are desired and is excellent to follow if the culture is to be started with one single isolated protozoan. After inoculation a pure culture usually requires several weeks to develop to a point at which it is best for laboratory study; and, furthermore, a "pure" culture seldom remains pure for any long period of time unless it is carefully handled, given additional food or subcultured.

In culturing protozoa the important factors to consider are temperature, light, kind and quantity of food, and freedom of contamination. These factors vary widely with the specific form to be cultured. Specific information will be given for each species but generally speaking ordinary room temperature is satisfactory for all, indirect light is better than direct sunlight, boiled timothy, wheat, rice, and other cereals may be used as food, distilled water or boiled pond water should always be used and the culture vessels may be battery jars or any other wide-mouth jars, but the best culture dishes are small 4½" diameter finger bowls. The stacking feature of these dishes makes it possible to have a number of cultures in a small place and enables one to keep closer check on food and contamination. All culture dishes should be cleaned and thoroughly rinsed to be free from all alkali and acid used in the cleaning process.

SARCODINA, AMEBOID PROTOZOA

AMEBA

To culture amebae from a local source, some decaying water plants (Elodea, algae, water lily, leaves) and pond water should be obtained. A little of the plant material and about 50 cc. of pond water may be placed in a finger bowl dish and observed daily. To save time it is usually best to start several cultures, using pond weeds and water from several localities. If



Protozoa

A. Sarcodina
B. Mastigophora

1. Amoeba proteus
2. Arcella vulgaris
3. Difflugia oblonga
4. Euglena viridis
5. Ceratium sp.
6. Paramecium caudatum

C. Infusoria
D. Suctoria

7. Didinium nasutum
8. Vorticella campanula
9. Stentor polymorphus
10. Euplotes patella
11. Spirostomum ambigum
12. Ephelota coronata

amebae are present, they should appear in quantities in about two weeks, being most plentiful on the bottom of the culture dish. In looking for them, pipette a few drops of the bottom sediment onto a slide and examine under the microscope.

Ameba appears to do best with a moderate temperature, diffused light and very little food. At 50° F. they are inactive and sluggish, at 75° they develop rapidly and at a temperature of 90° or higher there is little chance of their survival.

Direct sunlight is harmful to amebae and an over abundance of light encourages the development of other more vigorous protozoa which results in rapid contamination of the culture.

Ordinary stacking finger bowls make excellent culture dishes. Several dishes may be stacked one upon the other—and the top dish covered with a glass plate. Wheat kernels boiled for 2 minutes and pieces of timothy hay about 15 to 20 mm. in length, which have been boiled for 5 minutes, supply the source of food. Each culture is prepared with 250 cc. of distilled water to which 5 wheat kernels and 20 to 25 pieces of timothy are added. In about a week or ten days' time the culture medium in the dishes will contain bacteria and minute protozoa upon which amebae feed. A very good food for ameba is *Chilomonas* (see culture procedure page 6) and if a good culture of this species is on hand, inoculate culture medium first with Chilomonas and then with amebae from a pure culture or with specimens isolated from a mixed pond culture. The inoculation or transfer should, of course, be made with a clean pipette.

These cultures should be examined every week to check the food supply and the abundance of the amebae. In making up a dozen or more ameba cultures there are always a few that do not respond to the first inoculation. Often times the culture conditions may be unfavorable at first inoculation but the second attempt is usually successful. If not, try again and if no favorable results are obtained something is wrong and these cultures should be discarded. When checking the ameba cultures, should bacteria and infusoria show a decrease, a piece of boiled timothy and a kernel of wheat may be added. Afterward the amebae will have divided and increased to make a good rich culture and may then be used for class study. Ameba cultures will last from 4 to 12 weeks, but to keep active cultures on hand, subcultures should be prepared when the amebae are in good active condition, in the 6th to 8th week. As the cultures grow older and food is not added, they become inactive and encyst. If the cultures have been inoculated with one of the larger strains, the amebae can be seen plainly with the naked eye as tiny milky-white specks on the bottom and sides of the dish.

CHAOS CHAOS

Chaos chaos, the largest ameba known to science, was first seen by Röesel von Rosenhof in Germany in 1755. It has been found in nature only five times since then: in 1900 by H. V. Wilson in North Carolina; in 1902 by E. Penard in Switzerland; in 1916 by W. A. Kepner in Virginia; and by A. A. Schaeffer in Tennessee and by A. A. Schaeffer in 1936 in a marsh in New Jersey, who has succeeded in culturing it.

Chaos chaos is very similar in its general appearance to the common laboratory ameba, *Amoeba proteus*, but is much larger, attaining a length from 4 mm. to 9 mm. when in locomotion. It is easily seen with the unaided eye. The large size sometimes causes this ameba to break up in shipment but if the culture is left undisturbed for three or four days and Paramecia added as food, quick recovery of *Chaos chaos* will be observed.

Subcultures of *Chaos chaos* can be started by the method used for *Amoeba proteus*. However, *Chaos chaos* is a heavy feeder and for rapid growth it must have abundant food such as *Chilomonas, Paramecium,* and other ciliates.

ARCELLA

Arcella may be found on the bottom of old cultures, bottom ooze from shallow ponds and on water plants and algae. Cultures may be prepared and maintained by following the procedure given for culturing amebae.

MASTIGOPHORA—FLAGELLATE PROTOZOA

EUGLENA

Euglena is usually present in all collections of pond debris and is found in great abundance in pond scum during the summer months. It is one of the easiest protozoans to culture because it requires plenty of food, light and little attention. Battery jars or other wide mouth jars are excellent for culturing and a window sill is in ideal place to keep cultures since direct sunlight is beneficial. The temperature can range from normal to 90° with little damage to culture. Boiled wheat, rice or timothy may be used as food.

A clean 6 x 8 inch battery jar should be filled with distilled water and a large handful of timothy or 100 kernels of wheat or rice be added. Place the culture on a window sill and after a week add a few drops of concentrated *Euglena* from a pure culture or isolated from material collected in stagnant pools. In two weeks the entire culture will begin to have a greenish appearance and the surface of the water will be covered with a rich bacterial scum containing large numbers of *Euglena*. The culture will last for four weeks without any attention. If more food is added every two weeks and contamination avoided the culture will last three or four months.

CHILOMONAS

One of the most common species of protozoa is the small flagellate form, *Chilomonas*. Hay infusions and mixed pond cultures are usually teeming with it. It is taken as food by many species of protozoa and where the culture of *Amoeba, Paramecium, Stentor* and other species is undertaken, by keeping extra *Chilomonas* cultures on hand the food problem for these cultures is solved.

Cultures of *Chilomonas* may be made up in any size culture dish. In a small finger bowl the culture medium should be prepared with 250 cc. of distilled water and 8 kernels of wheat boiled 2 minutes. After two days the culture may be inoculated with specimens isolated from mixed cultures or from pure cultures. If neither is available, the culture jar should be left uncovered since cysts of *Chilomonas* seem to be ever present in the atmosphere and spontaneous inoculation will occur. Within a week or ten days the culture will be ready for use as study material or food for other cultures.

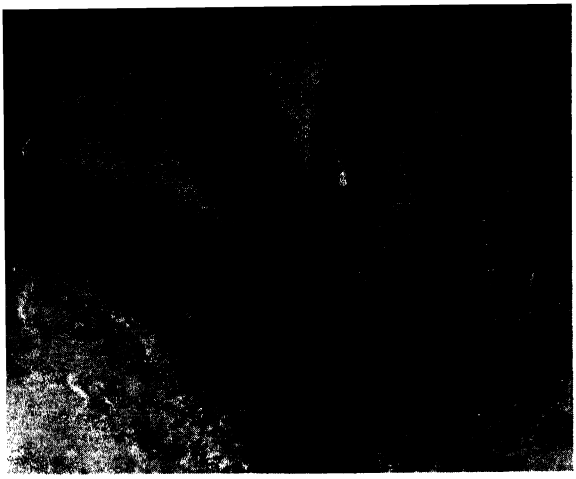
PERANEMA

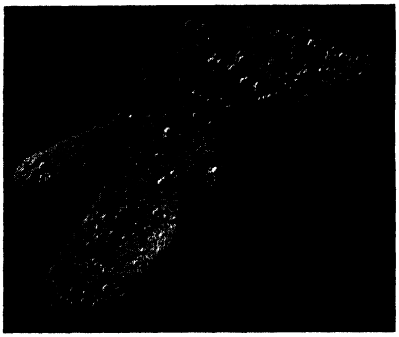
A very flexible protozoan which may be cultured in a medium consisting of 40 pieces of timothy 1½ inches long boiled for 5 minutes, and 12 kernels of wheat boiled for 3 minutes, added to 250 cc. of distilled water. Inoculate with *Peranema* after five or six days. The culture will grow from 6 to 8 weeks if food is added occasionally but it is advisable to prepare new medium and subculture.

CHLAMYDOMONAS

Although considered more in the algal group, *Chlamydomonas* is often used in class work for comparison with other flagellates. At certain seasons of the year, it is found in abundance in fresh water ponds and lakes.

To grow *Chlamydomonas* in large quantities, fill a flower pot with a good grade of clean white sand and place the pot in the usual flower pot saucer. Saturate the sand with pond water or culture containing *Chlamydomonas,* moisten the surface of the sand with a modified Knop's solution and keep the saucer filled with pond or distilled water. The *Chlamydomonas* will grow on the surface of the sand covering it with a layer of green. It is advisable to keep the pot covered to prevent the sand from drying out too rapidly. The growth on the surface consists largely of colonies but the motile forms are easily produced when placed in water. Ordinary room temperature is adequate and the culture may be placed where it will receive some sunlight a portion of each day.



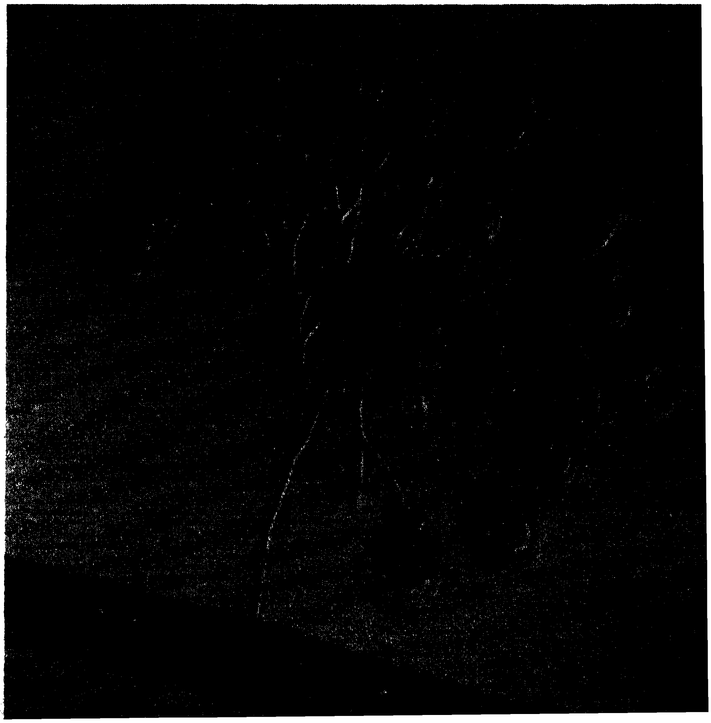


Living Protozoa

Upper: Living Stentor.

Middle: The ameba, Chaos chaos, photographed in relief.

Bottom: The colonial ciliate, Epistylis.



The formula for Knop's solution is as follows:

Solution A.	
Potassium nitrate KNO_3	2 grams
Potassium phosphate K_2HPO_4	2 grams
Magnesium phosphate $MgSO_4$	2 grams
Distilled water	600 cc.
Solution B.	
Calcium nitrate $CA(NO_3)_2$	8 grams
Distilled water	600 cc.

Keep the two solutions separate and mix equal parts of solution A and B before using.

VOLVOX

The colonial flagellate *Volvox* is found in ponds, lagoons and even along the margins of quiet lakes, especially during the warmer part of the summer. It is more frequently found in permanent pools which receive an abundance of rain water than in pools of a temporary nature.

No fool-proof method of culturing *Volvox* has been developed but cultures are usually kept in battery jars containing water from some pond in which it has been collected, or in water taken from a well balanced aquarium. Three to four *Elodea* plants added to the culture will help to keep the water clear and supply oxygen. Place the culture in a cool location where it will receive good light.

INFUSORIA—CILIATE PROTOZOA

PARAMECIUM

Paramecium may be found usually in any pond collection. The preparation of pure cultures is not difficult; they develop rapidly and require little attention. Ordinary room temperature is satisfactory for good continuous growth of the culture, but a temperature of 80° to 85° will bring the culture to its maximum growth in a shorter time. The best culture dishes for *Paramecium* are the 4½ inch diameter finger bowls because of the greater surface area and less depth of water. However, any type of glass container will do for this protozoan. Timothy, rice and wheat boiled about three minutes are good food for the culture. The culture will grow in direct and indirect light; however, the latter is best because direct sunlight encourages other protozoa and results in contamination.

The dishes for culturing should be thoroughly cleaned. If the 4½ inch diameter finger bowls are used, make up the culture with 250 cc. of distilled water and 8 kernels of wheat boiled 3 minutes. If larger culture jars are used, increase the amounts of food in proportion to the amount of water. Stack finger bowls to any desired height, cover the top one with a glass plate and place where they will receive plenty of indirect light.

If a culture of *Chilomonas* is available inoculate the culture two days after it has been prepared and after three days introduce the paramecia from pure culture or with specimens isolated from mixed culture. Three or four days after inoculation *Paramecium* will be seen concentrated near the surface of the water and around the food. In ten days to two weeks the concentration will be at its maximum. When the paramecia begin to die down a little, boiled wheat should be added to maintain the culture, or a new culture medium can be inoculated.

(Note: Write for free Turtox Bulletin on methods of culturing ***pure-line*** cultures of *Paramecium.)*

STENTOR

When looking for *Stentor,* collections of pond weeds and water should be placed in a large glass jar and left unmolested for 24 hours. By that time if any *Stentor* are present they will be seen on the sides of the jar facing the strong light and on the surface scum. The preparation of a pure culture from this pond collection may be accomplished easily. Because *Stentor* thrive in a rich protozoan culture containing *Paramecium, Colpidium* and *Chilomonas,* prepare the culture with this in mind. Follow the procedure given for *Paramecium.* When the culture shows good growth of *Paramecium* and *Chilomonas,* inoculate with *Stentor,* keep the culture in diffused light and in a temperature of 65 to 80° F. Extra food may be added from time to time, but it is advisable to subculture to new media frequently.

DIDINIUM

Didinium is an interesting protozoan because of its carnivorous habits. It lives mainly on *Paramecium* and other infusoria. *Paramecium* cultures should be developed and when the paramecia are abundant the *Didinium* may be added. The culture will last as long as there is a sufficient food supply. About every ten days more paramecia should be added or new *Paramecium* cultures should be inoculated.

Didinium encysts readily if food is lacking or the culture allowed to dry up. The culture may be kept in this condition until such time as active *Didinium* are needed. Then, some of the bottom debris should be added to a rich *Paramecium* culture and in a few days *Didinium* will appear.

BLEPHARISMA

The culture of the slow moving, peach-colored protozoan, *Blepharisma,* can best be carried on in shallow culture dishes in media similar to that used for amebae. It is better to increase the boiled wheat to ten kernels because *Blepharisma* grows best in rich cultures. Inoculation may take place two weeks after the culture has been started. The cultures develop quickly and require little attention from four to six weeks. This protozoan is usually found swimming slowly about near the bottom of the dish.

COLPIDIUM, EUPLOTES AND HALTERIA

These forms are commonly found in pond collections and can be grown in pure culture as easily as the other types discussed. The culture medium is similar to that suggested for culturing *Paramecium.* These forms may be easily isolated from the pond collection and used to inoculate the prepared culture medium. They develop rapidly and will have increased considerably a week after inoculation when they will be found in large numbers in the surface scum and upper half of the culture. Subcultures should be made every three weeks.

SPIROSTOMUM

Aquatic plant collections often contain numerous *Spirostomum.* Pure cultures are readily developed by preparing a rich culture medium (follow same procedure as suggested in the culture of *Euglena),* inoculate with *Chilomonas* for food and introduce the *Spirostomum* after 2 or 3 days. Subculture every 3 to 4 weeks.

VORTICELLA

Although *Vorticella* may be found the year around in ponds and lakes, attached to aquatic plants and dead vegetation, cultures of this protozoan are difficult to maintain in the laboratory.

The scum of a decaying pond weed culture is usually rich with colonies of *Vorticella,* but this is only a temporary condition. *Vorticella* may be transferred to a prepared medium as suggested for *Ameba.* In the culture, specimens will be found in the surface scum and on the bottom. Subculture should be prepared about every 2 or 3 weeks.

A culture of *Vorticella* added to a balanced aquarium containing fish will grow for many months. In such an environment the colonies will attach themselves and spread over the leaves of the water plants.

CARCHESIUM AND EPISTYLIS

Carchesium and *Epistylis* are found under the same conditions as *Vorticella*, but they appear in greater numbers in the late fall and early winter. The colonies may be removed from pond collections and transferred to a balanced aquarium where they will live for a long time providing the temperature of the water remains low, 50° to 60° F.

Occasionally when checking pond collections many other protozoa are found which are of interest. A few of the forms are *Frontonia, Urocentrum, Coleps, Lacrymaria, Ceratium* and others many which may be isolated and cultured in medium prepared as suggested for the culture of amebae.

Trichodina, the barrel-shaped protozoan found gliding up and down on the tentacles of fresh-water *Hydra* will grow in a balanced aquarium stocked with hydras. *Podophyra,* one of the Suctoria, may be cultured in rich *Paramecium* cultures. Subculture when food is low but avoid contaminating other laboratory cultures with this form.

INFUSORIA POWDER

Most people who have raised tropical fishes are familiar with the various "infusoria powders" now sold by many dealers. Such powders consist in most instances of dry and pulverized pond mud; they can be almost worthless or very rich in plant and animal life, depending upon where and when (and how) the material was collected. Turtox furnishes an infusoria powder consisting of dried surface mud and debris from three or more temporary ponds; this is collected during the late summer after the ponds have dried up due to natural causes, and the collections are, of course, made from ponds which supported an abundant aquatic life during the wet season. To this is added an equal weight of food, consisting of finely ground timothy hay, wheat, rice, soybeans and lean meat.

A little of this powder placed in a battery jar of distilled water will provide much very interesting study material. It contains many encysted protozoans and algae, many crustacean and insect eggs, most of which develop rather promptly when subjected to water and warmth. Such forms as *Euglena, Didinium, Colpidium,* and *Euplotes* usually appear within a week or ten days, to be followed rather soon by many kinds of algae, small crustaceans and aquatic insects.

Although mentioned at this point in connection with the culture of protozoans, the dry infusoria powders are a convenient source of supply (especially during the winter) for *Daphnia, Cyclops, Cypris* and mosquito larvae.

SALT-WATER CULTURES

Most teachers are familiar with fresh-water cultures of algae, protozoans, small crustaceans, etc.; but there seems to be little realization of the interesting possibilities of salt-water cultures. However, this field of experimentation is well worth looking into, for the requirements are simple and the results are tremendously interesting to any student of aquatic biology.

All surface sea-water which has not been boiled or carefully filtered contains a vast amount of microscopic life. The amount naturally varies with the season and the region, and water taken from near shore during the late summer or early autumn is usually richest in its living content. However, regardless of season, sea-water from any point near shore is certain to contain many living organisms and many parts of this "plankton content" develop rapidly and multiply in a laboratory culture.

The simplest salt-water culture consists of about a gallon of natural unfiltered sea-water placed in a glass battery jar and covered with a loose-fitting glass plate to keep out dust and retard evaporation. (The water-surface line should be marked on the outside of the jar with a wax pencil and pure distilled water added from time to time to replace that lost by evaporation.) Such a culture will at first appear to be quite clear and, aside from a few very minute crustaceans, it will apparently contain no visible living population. However, a large and varied population is present and very soon its presence will become evident. Algae will appear within a week or ten days. Diatoms increase rapidly, forming a brown scum on parts of the glass, and microscopic examination will reveal an amazing variety of shapes. Other algae—green, red and brown—usually appear and grow so long as the culture furnishes them with sufficient food. Some of the filamentous types such as *Cladophora* often make extensive growths.

But the animal inhabitants are likely to be even more numerous than the plants. The larval stages of many crustaceans appear and some few may even attain adult size in the culture. Various species of minute marine worms develop and not infrequently one finds embryological stages of several of the mollusks. Protozoans and rotifers are, of course, likely to be very abundant and it is interesting to compare them with the common forms found in fresh-water cultures.

Interesting cultures of mixed protozoans (and some other forms) will result if some scrapings from the external surface of fresh oyster shells (obtainable from most inland fish markets) are placed in dishes of natural or synthetic sea-water.

[To teachers who wish to maintain special cultures and rear specific salt-water forms, we can do nothing better than suggest the many detailed directions (each written by a specialist) contained in "Culture Methods for Invertebrate Animals" edited by James G. Needham and published by Comstock Publishing Company, Inc., Ithaca, New York.]

PORIFERA

MARINE SPONGES

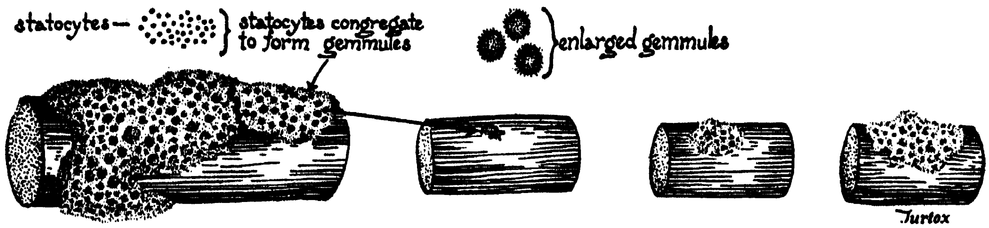
All commercial sponges originate in the ocean and are limited for the most part to tropical seas. Many kinds are found in the shallow waters off the coast of Florida from Key West to Tarpon Springs. However, it is not practical to attempt to transport living sponges of this type, although they are occasionally seen in large aquaria located at or very near the coast.

There are many other marine sponges of no commercial value and some of these occur in great abundance at least as far north as the coast of Massachusetts. In this class is the well-known *Scypha (Grantia)* and many small encrusting species which grow upon old wharf pilings and similar supports. One red encrusting sponge grows commonly on oyster shells and may often be secured from shell oysters sold in inland fish markets. We have not found it possible to keep *Grantia* or any of the encrusting sponges alive for more than a week or so in small marine aquaria, although it is likely that some of these smaller sponges would live for long periods in large tanks equipped with running sea-water.

FRESH-WATER SPONGES. *(Spongilla sp.)*

Fresh-water sponges are commonly distributed throughout the United States, occurring in ponds, lakes, reservoirs and slow-flowing streams. Although they begin growth in the early spring (starting from winter bodies or gemmules), the sponge colonies do not usually become sufficiently large to attract attention until late summer or early autumn. Then they may be found as encrusting masses (green, tan, brown or whitish in color) on submerged branches or logs and sometimes on aquatic plants and on the wooden sides of reservoirs. *Spongilla* most often occurs in rather shallow water and in a shady location.

Care of the Colony. All or a piece of the sponge colony may be placed in a balanced aquarium. In some cases, the colony will live for many months, making new growth and increasing in size very slowly. More often, however, *Spongilla* colonies collected in the autumn will form winter bodies (gemmules) after a week or so. These gemmules live over until conditions are favorable for their growth and, after forming them, the parent colony dies and disintegrates.



Diagrammatic representation of the life cycle of Spongilla.

Care of the Gemmules. During the autumn or early winter, it is easy to grow young sponge colonies from the gemmules. Fill a shallow pan or dish with pond or aquarium water and place in it a number of clean glass microscope slides. Drop a few gemmules on each slide and set the dish away in a dark place where the temperature is about 70° F. Do not disturb it for a week or ten days. At the end of that time, most of the gemmules will be attached to the glass slides and some of them will be wholly or partly surrounded by a fuzzy, whitish substance. This is the start of the new sponge colony, which, when placed in a large balanced aquarium will often grow to appreciable size. Examine both the dormant gemmules and the young sponge colonies under the low power of a compound microscope.

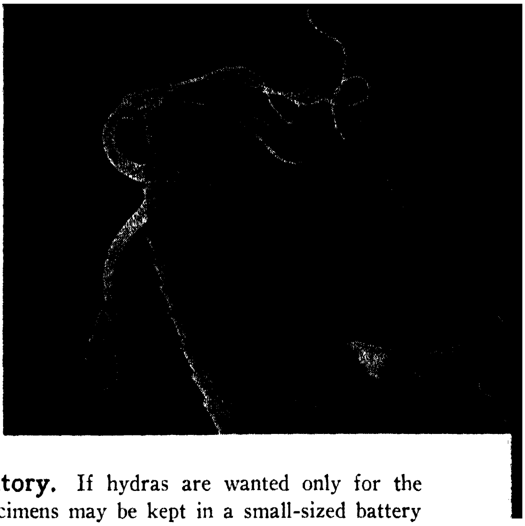
COELENTERATA

HYDRA. *(Pelmatohydra oligactis, Chlorohydra viridissima* **and others.)**

Hydras are found in nearly all permanent bodies of fresh water, but are much more abundant in some places than in other localities where the conditions are seemingly just as favorable for their growth. In general they are likely to be found in lakes, slow-flowing rivers and reservoirs, rather than in springs and swiftly-flowing streams.

Where to Collect. It will be rather difficult for the beginner to locate hydras in the field as the specimens contract when the water weeds to which they are attached are removed from the water. Look for this form in permanent pools or small lakes or even in flowing streams or rivers. In the Chicago area one species is found upon the rocks along the shores of Lake Michigan where the waves continually pound the shore. When collecting, look for hydras on the submerged water weeds. Place a few of the weeds in a quart jar of clean pond water and examine it by holding it up to the light. The specimens will usually remain contracted for some time and will appear as tiny lumps of jelly with the shortened tentacles projecting outward from the free end of this lump. Do not give up the quest quickly, but make a thorough search. At certain seasons of the year hydras may be very abundant, while at other seasons only an occasional specimen will be seen.

If specimens are located, collect a quantity of the water plants to which they are attached and take them to the laboratory in a pail of water. Place these weeds in pans of water and the hydras will gradually expand so that they can be seen, and they may even come to the surface and hang suspended from the under side of the surface film. If a large glass aquarium tank is available, a quantity of weeds may be placed in this aquarium and the tank filled with water. After the specimens have expanded, they may be seen easily by looking through the aquarium from the side. To obtain individual specimens, clip off small portions of water plants to which hydras are attached and place in another container of water.



Right: Living hydras attached to the leaf of an aquatic plant under water.

How to Care for Hydra in the Laboratory. If hydras are wanted only for the time the class will be studying them, the living specimens may be kept in a small-sized battery jar or in a finger bowl full of pond or aquarium water. However, if they are to be kept for a considerable period, a fairly large balanced aquarium containing growing water plants (but no fish!) will be needed. Release the hydras in it and they will soon attach themselves to the water plants and the glass sides of the tank. In handling living hydras, two important points must be kept in mind; first, water from most city water supplies will prove fatal, and they should therefore be provided with natural pond water or water taken from a balanced aquarium; and second, rapid temperature changes are usually dangerous. Hydras must be kept cool, for they can stand high (70° F.) water temperatures only when the temperature has increased very gradually.

To grow hydras successfully, two things are necessary—a good supply of patience and plenty of *Daphnia.*

Hydra seems to do well in water which contains a slight amount of boiled aquatic plants. A very slight amount of fermentation seems to be beneficial if the water remains perfectly clear. Water thus prepared should stand for several days before the hydras are added. However, we have been equally successful in rearing them in a small balanced aquarium of one-gallon capacity in which were growing one plant of *Vallisneria,* one of *Sagittaria* and one of *Elodea.*

Hydra is a hearty eater and, if the culture is to do well, it must be fed plenty of *Daphnia.* This means that an active culture of *Daphnia* is necessary when the hydras are to be kept over winter.

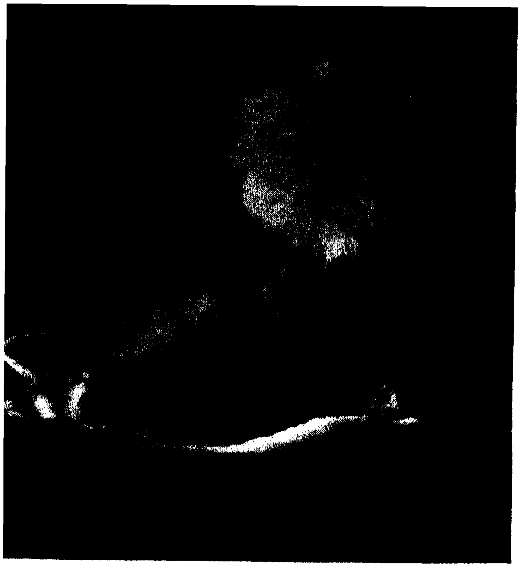
Feeding. As has already been pointed out, *Daphnia* is an excellent food for hydra, but any other small crustacean such as *Cyclops* is also acceptable. It is impossible to keep living hydras in the laboratory for any great length of time unless a regular supply of living food can be maintained for them.

To demonstrate the feeding habits of hydra to a group of students, pipette a few drops of water into a Syracuse watch glass and place a hydra in this. Then add one living *Daphnia* and the hydra will soon entangle the crustacean in its tentacles, draw it into its oral cavity and consume it.

Reproduction. Hydra reproduces by means of buds and by sex cells, but usually the two types of reproduction occur at different times. When well fed, they will develop buds very rapidly and in the course of a few days these buds become detached from the parents and begin their independent existence as distinct individuals.

Usually the sex organs (spermary and ovary) are found on different animals, but occasionally both will occur on the same individual. Fertilization and the early development occur while the egg is still attached to the parent. Hydras also produce winter eggs which are fertilized in the autumn and lie dormant until spring.

Depression. Anyone who attempts to keep living hydras for a considerable period will sooner or later find that, in spite of plentiful food and other favorable conditions, they will begin to die off. This is usually due to "depression," the causes of which are not clearly under-



Left: Sea anemones photographed in a six-gallon school aquarium. Many marine animals will live for long periods in small aquaria and hundreds of inland schools now give their pupils an opportunity to study living plants and animals from the ocean.

stood. Depression is that slow contraction often found in hydras, where the body stalk shortens and the tentacles contract until they become nothing but stumps, this continuing until the hydra becomes a small round ball and dies. During this period, they refuse to eat and it was once thought that starvation was the cause of depression. Dr. L. H. Hyman, of the American Museum of Natural History, suggests four possible reasons for depression: (1) The temperature of the water rising to more than 20° C. (2) Insufficient oxygen in the water. (3) Excess fermentation present. (4) Changing of the hydras to water different from that in which they were collected.

In our own laboratory, we have noticed depression as a result of all of these conditions, but it also occurs at times when no reason is apparent.

(*Note:* To maintain hydras in quantity, a constant supply of living *Daphnia* (or other small crustacean) *must* be provided. See section on *Daphnia* for culture methods.)

MARINE HYDROIDS. *(Obelia, Sertularia, Tubularia* and others.)

Some of the colonial hydroids which occur in such abundance on our sea-coasts will stand shipment and can be maintained for short periods in small marine aquaria. The northern forms should be collected during the colder months and should be transported in wooden tubs or pails of natural sea-water. The aquarium water in which they are placed should be well aerated and the water temperature should be kept below 60° F. Under such conditions the colonies will sometimes live for several weeks but seldom grow or increase in size. In sea-coast aquaria equipped with running sea-water marine hydroids often grow in great abundance. (See section on *Marine Aquaria* in appendix.)

JELLYFISHES

None of the marine jellyfishes is suitable for inland aquaria. They are fragile, very difficult to transport, and such forms as *Aurelia* and *Gonionemus* can be studied in the living condition only at the sea coast.

Craspedacusta ryderi, often referred to as the fresh-water jellyfish, is the medusa stage of a little known fresh-water hydrozoan. It occurs erratically in lakes and streams, sometimes in great abundance, sometimes missing for several years. When found it can be placed in a fresh-water aquarium where some of the medusae may live for several weeks. Its hydroid stage is so rarely found that the average teacher is most unlikely to encounter it.

SEA ANEMONES. *(Metridium* and others.)

Many kinds of anemones will live in small marine aquaria and few animals are more beautiful or more interesting for laboratory study. As is the case with most marine forms, small specimens should be selected, and they should be removed from the rocks or pilings very carefully. A dull-bladed putty knife is a good collecting instrument and care should be taken to avoid injuring the base of the animal. If purchased, the living sea anemones are best ordered during the cooler months, when they ship well to the more distant inland points.

Anemones may be fed small fragments of raw oyster, clam or fish. Drop these small bits of food onto the extended tentacles, using a pair of wooden forceps to present the food. Do this gently and avoid making any commotion in the surrounding water. In our Chicago laboratories, we have maintained living sea anemones for many months in marine tanks of only 6 gallons capacity.

(Refer to section on *Marine Aquaria* in appendix.)

NORTHERN CORAL. *(Astrangia danae.)*

The tropical corals are unsuitable for shipment or for study in small aquaria; but the common Northern coral (*Astrangia danae*) stands transportation very well. It will not increase or grow permanently in an aquarium, but in a properly aerated marine tank it will sometimes live for a month or longer. The living polyps are most interesting to inland students, most of whom think of "corals" as being the dead and calcareous accumulations left after the actual coral animals have died.

ECHINODERMATA

STARFISH AND SEA URCHINS. *(Asterias, Arbacia* **and others.)**

Starfish and sea urchins of many kinds are plentiful on most sea coasts and are splendid forms for aquarium study. They are easily collected, not difficult to transport, and are quite long-lived within the confines of small tanks. Like many other marine animals, they prefer a low temperature and well-aerated water, as explained under *Marine Aquaria* in the appendix of this booklet.

Starfish feed upon snails, clams, oysters, and other small mollusks and it is best to provide them with living food. The common snails, *Nassa* and *Urosalpinx,* and small clams such as *Mytilus, Ensis,* and *Venus* are suitable. In the absence of living food—and, if the starfish are hungry enough—they will sometimes accept snail shells stuffed with pieces of raw clam or oyster. Sea urchins accept pieces of raw clam, oyster, fish, or even lean beef.

PLATYHELMINTHES

PLANARIA. *(Euplanaria dorotocephala* **and others.)**

Living planarians are easily collected and kept in the laboratory and their remarkable powers of regeneration make them of unusual value in laboratory work. By following the simple steps outlined here, little difficulty will be experienced in keeping live specimens and demonstrating the phenomenon of regeneration.

Obtain living specimens by collecting in the field or by purchasing. Turtox can supply these in any quantity at all times of the year. The smaller species, *Euplanaria maculata,* is easily collected in most localities. Look for them on the under sides of stones or on aquatic vegetation in pools or streams. The larger species, *Euplanaria agilis* or *Euplanaria dorotocephala,* are found in cold springs or spring-fed pools or streams, and can be captured by laying pieces of raw beef at the margins of the water. When the worms attach themselves to the meat, they may be shaken into the collecting jar.

When the worms have been brought to the laboratory, place them in a granite dishpan about half filled with clear water. (Pond water is best, but aerated tap water may be used.) Cut a round piece of tin to serve as a cover to shut out the light.

Feed the worms every four or five days by placing in the pan small pieces of fresh calf or beef liver. It is interesting to note how quickly the worms can locate the food. After two or three hours, the worms will become gorged and leave the meat. At this time, the food must be removed and the water changed, because planarians cannot live in water which contains any decaying organic material. Agitate the water so that the animals will drop to the bottom of the pan, clean the organic material from the sides of the container and decant all the water. Pour on fresh water and, if not clear, repeat the process. Be sure every bit of meat is removed.

The above directions are particularly applicable to *Euplanaria dorotocephala.* The smaller pond planarians (*Euplanaria maculata*) will live quite well in small balanced aquaria without special feeding or other attention.

(*Note:* Directions for using planarians for regeneration experiments are outlined in the free Turtox Service Leaflet No. 16.)

WHITE PLANARIAN. *(Procotyla fluviatilis.)*

This white, semi-transparent planarian is found in both fresh and brackish water, on the dark sides of stones and on submerged aquatic plants. It occurs in greater abundance in the New England states, but may also be collected in some of the other northern states east of the Mississippi river. Because it does not respond to meat baits, it is not easily collected.

Procotyla is a difficult species to keep under laboratory conditions. It generally refuses to feed on meat, which is so readily accepted as food by many other species of fresh water planaria, but requires living animals such as *Daphnia, Cyclops,* and similar small crustaceans.

NEMATHELMINTHES

VINEGAR EEL. *(Anguillula aceti.)*

The vinegar eel is a free-living round worm found very commonly in bulk cider vinegar, in which it increases rapidly. Because it is quite transparent, it is easily examined under the microscope, and, being viviparous, all stages of development may be studied.

Cultures of vinegar eels of considerable volume (one quart or more) will live in the laboratory for several months with little or no attention. Smaller cultures may be maintained indefinitely if some of the worms are transferred to fresh vinegar every two or three weeks. (*Note:* Use only natural bulk cider vinegar; bottled vinegar which has been chemically treated is not suitable.)

HOOKWORMS

Write for special free Turtox Bulletin discussing culture methods for infective hookworm larvae.

TROCHELMINTHES

ROTIFERS. *(Philodina, Hydatina* **and others.)**

Rotifers, or wheel animalcules, are very abundant and widely distributed, occurring in fresh and salt water and even in the waters of temporary ponds and ditches. They often appear in laboratory aquaria and are frequently abundant and unwelcome inhabitants of protozoan cultures. Most of them are quite transparent and microscopic, although a few are large enough to be seen with the naked eye. Some live on plant material, while others eat protozoans and other microscopic animals. Nearly all rotifers one ordinarily sees are females. In some species the males are not known and the eggs apparently develop without fertilization.

A jar of pond water containing a little algal growth and some dead water plants will soon develop a rotifer culture. *Philodina* may be cultured easily by the hay infusion method or by other methods commonly used for culturing *Paramecium.* In old protozoan cultures, rotifers often appear in great abundance, and a more than adequate supply can be maintained with little effort. Marine rotifers are usually present in salt-water aquaria and in older marine cultures.

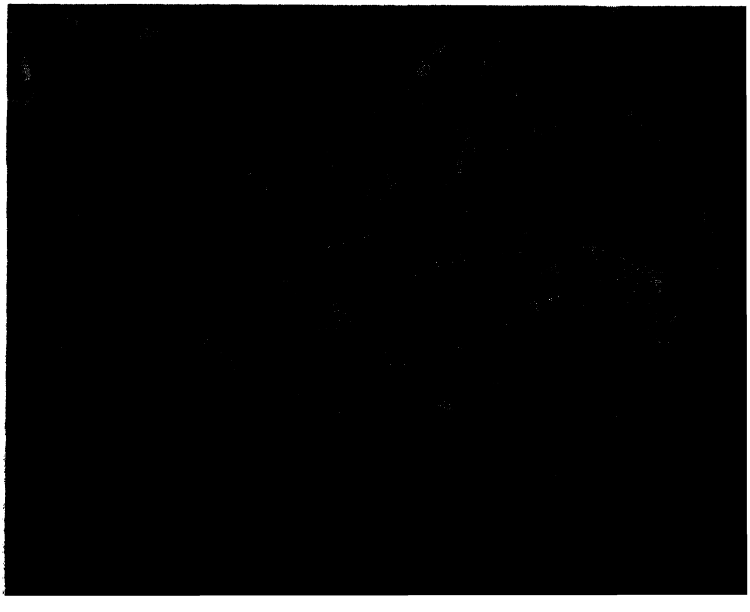
ANNELIDA

EARTHWORMS. *(Lumbricus terrestris.)*

Adult Worms. Any one of several methods will be found satisfactory in keeping living earthworms over rather lengthy periods until called for in the laboratory work. If the basic requirements are provided, such as: proper temperature, moisture, fresh food and lack of crowding, one may have success regardless of the specific plan he follows.

The simplest method by far is to keep the worms in a box of humus and leaf loam. Secure a wooden box (free of cracks and holes) from your grocer—a prune box will suffice—and fill it to within about two inches of the top with a mixture of rich humus, leaf mold and some old leaves. Never use a heavy soil such as clay. Be sure that this mixture is moist, but *not wet.* Make a hole in the center and add the worms—not too many, no more than about forty specimens to this size of box. All worms should have been sorted over carefully to make sure that each is in good condition. Injured worms die quickly and foul the culture box immediately. Little or no food need be given to this culture as the old leaves serve as food. If leaves are omitted from such a culture, feed sparingly of bread soaked in milk, cooked oatmeal and corn meal. The food is placed in a small hole in the dirt and is covered over with about one inch of soil. Vary the diet by placing a small portion of a leaf of lettuce on top of the soil occasionally.

Place a sheet of metal or a pane of glass over the top and store the box in a basement



Right: A pair of copulating earthworms. This flashlight photograph was taken on a rainy night.

where the temperature is not apt to go higher than about 60° F. Examine the culture periodically to be certain it is progressing properly. Add just enough water to prevent excessive drying.

Lumbricus may also be kept in boxes or cans of damp Sphagnum—if the temperature does not exceed 60° F. We recommend this method for temporary storage—a few days to a week or two. High temperatures cause the moss to ferment and the worms will die almost immediately. Avoid having the moss dripping wet; it should merely be kept damp.

Cocoons of either *Lumbricus* or *Eisenia* are usually available and Turtox regularly supplies the latter at all seasons. Ordinary petri dishes lined with two or three thicknesses of filter paper are suitable receptacles for the cocoons. Moisten the paper and place the cocoons on it; then replace the cover of the dish. The younger cocoons have a greenish-yellow appearance; the older ones are dark brown or red. When the young worms emerge from the cocoons, they may be kept in small containers filled with loam and leaf mold, or may be kept in petri dishes containing loam and fed upon small bits of crushed lettuce leaves.

AQUATIC ANNELID WORMS. *(Tubifex and other fresh-water forms.)*

Tubifex and other aquatic annelids are found in the mud at the bottom and along the shores of most bodies of fresh water. They can be seen moving aimlessly above the mud and when disturbed retreat into their slime and mud tubes. Some species live in decaying vegetation and others are found in considerable numbers in floating masses of algae.

Aquatic earthworms are collected with the mud or decaying debris in which they live and are then washed free of the mud by placing the collected material in cheese cloth or fine-screened sieves.

It is easy to keep a culture of these worms growing in an aquarium. A layer of mud about an inch deep, containing *Tubifex* and other aquatic worms is placed on the bottom of the tank and covered with a half inch layer of sand. The tank is prepared as a balanced aquarium with plants and animals. After the water has cleared, the *Tubifex* will be seen, their bodies extending above the sandy layer. Jarring the aquarium will cause them to retreat momentarily. It is wise to keep fish out of the tank in which *Tubifex* and other small aquatic worms are kept since they will eat them.

Aquatic earthworms are good fish food. To obtain them in quantity free of mud, they should either be washed clean as stated above or the mud containing the *Tubifex* and other species may be placed in shallow pans over a warm radiator or low flame. The warmth drives the worms to the surface, where they may be collected in concentrated masses.

ENCHYTRAE. *(Enchytraeus albidus.)*

Every fish fancier knows "enchytrae" as one of the best foods for his fish. Equally important is it for food for fish in laboratory aquaria and for the small salamanders such as red-spotted newts. The scientific name of this "domesticated" annelid is *Enchytraeus albidus.*

The cultural methods for this form are quite similar to those of earthworms. Secure a tight wooden box from your grocer (such as a prune box) and fill it up to within two inches of the top with rich humus, sifted to remove coarse particles. Place the original culture in a hole in the center. Cover it over with humus and then cover the box with a wooden or glass cover to prevent it from becoming dry. Place the box in a cool basement, the temperature should not become higher than from 60-65° F. Add water sparingly—just enough to keep the humus damp.

Feed *Enchytraeus* bread soaked in milk by working small holes in the humus, filling them with the food and covering over with an inch of humus. Alternate foods are cooked oat-meal, mashed potatoes, mashed potatoes mixed with rich chicken broth and the like. Feed worms sparingly about twice a week, but never until previous food has been consumed. If food sours, remove at once.

For freeing the worms of dirt when ready to feed them to the laboratory animals, place a quantity of them, dirt and all, in a glass jar or paper cup and fill it one-quarter full of water. Within 30 minutes, the worms will have crawled up the sides where they may be secured free of all dirt.

LEECHES. *(Hirudo, Haemopis* and others.)

Leeches are to be found in almost every standing pond, ditch, lake and sluggish stream. Many of them are beautifully colored and add much attractiveness to the ordinary balanced fresh water aquarium. Their care is simple and yet their behavior is of great interest. Although a number of leeches are to be found in local ponds, the one most commonly studied in the laboratory, both preserved and living, is the imported medicinal leech, *Hirudo medicinalis.* Of particular interest is the giant leech, *Haemopis grandis,* the largest American species which is now much used in school laboratories. *Hirudo medicinalis* is still used in medicine, to a small extent. This practice was so prevalent in Europe many years ago that "leech" became practically synonymous with "physician."

Leeches may be fed pieces of raw meat or raw fish. They can live for long periods without food.

Care in the Laboratory. Each year Turtox imports large numbers of the medicinal leeches from France. They usually reach us packed in damp earth. In fact, they can live in this condition for relatively long periods of time. For actual study it is much better to keep them in balanced fresh water aquaria. Care should be taken that the aquarium is well supplied with the large oxygenating plants such as *Elodea, Vallisneria* and the like. Place the aquarium so that it receives very little direct sunlight, as leeches prefer darkness. Provide stones, leaves and other opaque objects under which they may hide to escape the light. The usual animal population of the aquarium, such as small fish (bullheads, sunfish and the like), tadpoles, small crayfish, salamanders, snails and insect larvae should be kept in the aquarium. The excess food given the fish promotes the growth of the small forms which in turn furnish some of the food of the leeches.

Most leeches will partake of blood at some time during their life. Some are parasitic upon turtles, frogs, salamanders and fish. Although it isn't essential that they have blood to live for only a month or two, it is interesting to know just what kinds of blood they prefer. The turtle is frequently used to supply the blood for live leeches.

Leeches have lived in our aquaria, practically without attention, for as long as a year. Teachers will experience no difficulty in maintaining them for experimental purposes.

NEREIS VIRENS. (and other marine Annelids)

Nereis virens, the sand worm or clam worm, is a plentiful and well known marine worm of the Atlantic Coast, and, next to *Lumbricus,* is the most generally studied annelid. If placed in a good sized salt-water aquarium, *Nereis* may live for several weeks (sometimes longer); but, because of their feeding and burrowing requirements, these worms cannot be expected to live for extended periods in confinement.

Other interesting marine annelid worms which will live for short periods in aquaria are: the lugworm (*Arenicola cristata*), *Chaetopterus pergamentaceus, Clymenella torquata,* and *Phascolosoma gouldi.*

All of the Living Specimens Mentioned in this Booklet . . .

are obtainable from the General Biological Supply House. Our constant-temperature laboratories in Chicago, our marine stations on the Massachusetts and Florida Coasts and our corps of field collectors in all parts of the United States enable us to supply a great variety of living specimens—both plant and animal—at all seasons of the year. Regardless of where your school is located and regardless of weather conditions, you can secure top quality living specimens from Turtox.

CRUSTACEA

BARNACLES. *(Balanus* **and others.)**

Barnacles are an abundant and very well known form of marine life and are easily collected from rocks and wharf pilings. One or more species (usually *Balanus balanoides* or *B. eburneus*) are included in most of our marine aquarium assortments, for they live quite satisfactorily in small aquaria and are interesting arthropods for observation. Feed them very small amounts of minced clam or oyster; the pieces must be very minute—tiny fragments which float readily in the water. (Refer to general suggestions on *Marine Aquaria* in appendix.)

FAIRY SHRIMP. *(Eubranchipus vernalis* **and others.)**

During the late winter or early spring, it is not uncommon to find small pools containing thousands of fairy shrimps. All disappear after a few weeks and the pools in which they lived, being of a temporary type, may dry up completely during the summer months. Not so many years ago, the fairy shrimp was pointed to as a splendid proof of the theory of "spontaneous generation"; it appeared in unbelievable numbers in pools formed by the melting snow, it disappeared as suddenly as it had come and then in a few weeks the pool in which it had lived became a dry and dusty bit of ground. The explanation, of course, as every teacher now knows, is that this creature produces resting eggs which sink to the bottom and live in a dormant stage for long periods. Indeed, some of these eggs appear to require drying before they can develop, and all fairy shrimp eggs can go through extended periods (several years) of drought and freezing without harm. When conditions are again suitable (when the spring thaws flood the pools), they hatch and thousands of fairy shrimps again swim about.

Eubranchipus when adult is about one inch in length and reddish or bronze in general coloration. The females are larger and usually much more plentiful than the males. All species of fairy shrimps swim on the back, propelling themselves rather gracefully by means of their eleven pairs of waving gill-feet. They feed upon diatoms, protozoans and other microscopic forms.

We have never been able to discover any dependable way of maintaining permanent laboratory cultures of *Eubranchipus*, although dormant eggs brought into the laboratory and placed in water will usually hatch at any season. Specimens collected in the spring will usually live for several weeks in jars or aquarium tanks. The temperature of the water should be kept as low as possible, as high temperatures hasten their development and shorten their life span.

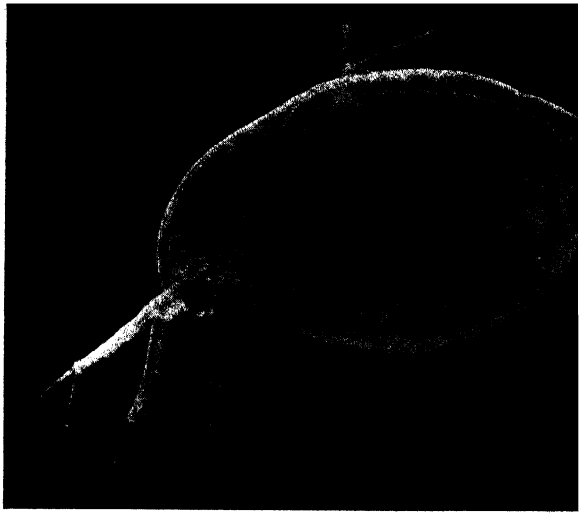
DAPHNIA

Daphnia (or "water-fleas") of various species can be collected in small quantities ordinarily by swishing a fine-meshed net among the aquatic plants growing in shallow water. At some seasons, often during the autumn, *Daphnia* and other small crustaceans occur in great abundance in the shallow waters of stagnant ponds and ditches. Since *Daphnia* are used so commonly in feeding hydras and small aquarium fishes, it is well to keep cultures of them in the school laboratory.

If *Daphnia* are collected locally, culture them in the water in which they are found. If the specimens are not obtained locally, use pond water or water from an established and well balanced aquarium.

It is only fair to admit that we know of no "sure-fire" method of maintaining permanent cultures of *Daphnia.* Many methods have been tried and some of them with a good degree of success, but no perfect culture method which will work under all conditions has yet been discovered. The more successful methods use rather large containers—usually wooden tubs or barrels having a capacity of from twenty-five to one hundred gallons. Four or five cultures

Right: A living Daphnia, greatly enlarged.



should be maintained, for then there is a good chance that at least one culture will contain numerous *Daphnia* at any given time.

Professor Harold Heath of Stanford University recommends the following method:

"Use one ounce (by weight) of dried sheep manure to one gallon of water. A wooden trough holding twenty-five gallons of water is used as a container. After the sheep manure and water have been in the trough for two or three days, the *Daphnia* are added. A few lettuce leaves are placed in the culture from time to time and are replaced by fresh leaves as they become thoroughly decayed."

Other foods frequently used include bone meal, decayed masses of algae and decayed aquatic plants. Keep the culture in subdued light and in a place where the temperature is fairly constant at 65° to 70° F.

OTHER SMALL FRESH-WATER CRUSTACEANS

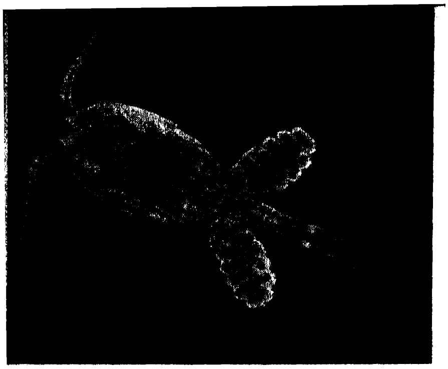
Such forms as *Cyclops, Cypris, Gammarus, Latona,* etc. will usually be present in small numbers in any large and long-established *Daphnia* culture. *Cyclops* and *Cypris* may be maintained for long periods in battery jars of pond water with a bottom layer of mud, dead leaves and well decayed bottom debris. *Gammarus* will live and breed in any small balanced aquarium, providing there are no fish present.

BRINE SHRIMP. *(Artemia salina.)*

The brine shrimp, *Artemia salina,* is a phyllopod crustacean of very general distribution. It is extremely interesting as a marine crustacean which can be reared easily and studied in the school laboratory, and it has great practical value as a constant source of living food for hydras and small aquarium fishes.

The resting eggs of the brine shrimp float in the water and require drying before they will hatch. This feature makes them *available at all seasons,* for the dried eggs remain viable (alive) for several years if kept in a dry and fairly cool place. Eggs may be collected at certain seasons on the sea coast, or may be purchased from dealers at any time.

Hatching the Eggs. The eggs hatch very quickly (within 24 to 48 hours) after being placed in a brine solution which is kept at a temperature of 70° to 75° F. Natural or artificial sea-water may be used if available. However, the brine solution used as a hatching medium may be almost any concentration from about 0.1% to 6%. When sea-water is not available, make up a brine solution by adding two teaspoonfuls of common table salt to one quart of water. After hatching, the larval stages (nauplii) may be used as a food (see below) or may be transferred to other containers for further development. If thousands are allowed to remain in one container, they will die after a few days for lack of food and sufficient oxygen.



Left: A female Cyclops carrying egg sacs.

Rearing the Shrimp. If you wish to rear *Artemia* to maturity and establish a permanent culture, place only a few of the larvae in a quart container of brine solution and supply them with food. Yeast is a satisfactory food, as are also various of the one-celled floating algae. The latter will usually appear in a culture of natural sea-water rather soon and will eventually appear in any brine solution in which the brine shrimp eggs (together with the natural debris attached to them) are placed. For quicker results, scrape some of the green slime from the glass side of a fresh-water aquarium and place a little of this in the brine shrimp culture. (Many of these unicellular fresh-water algae will grow in a weak brine solution as readily as they grow in fresh water.)

Use as Food. For feeding hydras, the larval brine shrimp may be concentrated by straining the culture solution through a piece of fine-meshed cloth. They are then placed in the fresh-water tank containing the hydras, where they will live for several hours, usually long enough to provide the hydras with ample food. Because of the very low cost of the eggs and the great rapidity with which they hatch, new cultures can be started every few days if a constant food supply is wanted.

The earliest larval stages are also very useful as food for small tropical fishes; or the brine shrimp may be allowed to develop and grow larger if they are desired as a living food for larger fishes.

Laboratory Study. Be sure to examine the eggs (both dry and hatching) and the nauplius larvae under the microscope. It is a most interesting study and permits you to show your students the continuous development of a marine crustacean

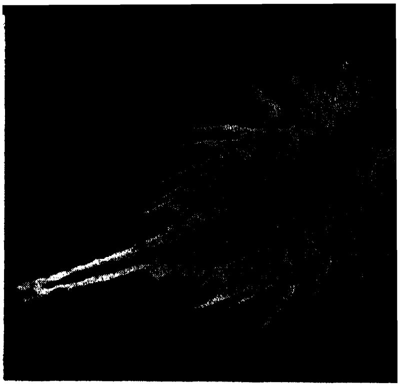
CRAYFISH. *(Cambarus* **and others.)**

Crayfish are of very general distribution and adult specimens can usually be obtained in lakes, ponds, and streams without difficulty. Being to some extent nocturnal, they hide during the day and will be found by lifting up flat stones or other objects under which they retreat for protection. In places where crayfish are plentiful it is usually possible to secure small specimens by swishing a net around among the aquatic plants or by dipping up netfuls of bottom debris. Crayfish which are to be kept in aquaria in the laboratory should be collected from ponds or quiet rivers, as those taken from fast-flowing streams are less likely to live in captivity.

In the late autumn or early spring look for the females carrying eggs upon their swimmerets. If one is found take her to the laboratory, place her in an aquarium and watch the eggs develop into young crayfish. Often females carrying young will be found in the early spring, although within a few days the fully developed young will leave their mother's swimmerets to shift for themselves.

The crayfish is one of the most interesting forms to keep in the laboratory and two or three should be included in one of the larger aquaria. Students will learn more of the habits of this animal by observing a few living specimens than they will by reading chapters of textbook material. An adult may be placed in a gallon battery jar containing clear water and the students can observe the movements of the mouth parts, antennae and appendages. Feed the specimen a small piece of raw fish or beef and observe its method of taking food.

Right: Larval stage of the brine shrimp, Artemia salina.



Crayfish often uproot or otherwise disturb the plants in an aquarium when they are provided with stones under which they may retreat. Therefore, it is a good plan to have a loose pile of good-sized stones in one corner of the aquarium and also to select *small* crayfish as aquarium inhabitants. Two or three specimens measuring about two inches in length are enough for a six gallon tank.

Care upon arrival. If you purchase living crayfish give them immediate attention upon delivery. If the shipping container is dry, place the crayfish in water—either in aquarium tanks or in shallow containers of water. Use pond (not tap) water if it is available. If the crayfish are shipped to you in water, transfer them to your aquarium tanks only after the temperature of the water in their shipping container has become approximately the same as the temperature of the water in the aquarium tanks.

GLASS SHRIMP. *(Palaemonetes exilipes.)*

This fresh-water shrimp is commonly called "glass shrimp" because of the remarkable transparency of its body. It is a common form in many of the ponds and streams of the southern states, is an interesting crustacean for laboratory study and a valuable scavenger for the balanced aquarium. It lives well in either a small or a large balanced aquarium, but prefers a tank containing plenty of vegetation. It lives harmoniously with most small fishes, but must not, of course, be placed in an aquarium containing fishes large enough to eat it. *Palaemonetes* will sometimes breed if a considerable number of individuals are kept in a large aquarium; and the females carrying eggs are particularly interesting for study. When hatched, the young shrimps are very small and will form food for even the smaller fishes unless they are immediately transferred to a tank where this danger does not exist.

The glass shrimp is largely a scavenger in its feeding habits and is therefore useful in keeping the aquarium clean. It will eat particles of fish food but occasionally should be fed tiny pieces of oyster, raw fish or raw meat.

MARINE CRABS

Most species of marine crabs will live for long periods under laboratory conditions and three or four small specimens may be kept in a 6-gallon salt-water aquarium. The bottom of the tank should be covered with an inch or two of sand and some piles of stones should be provided for the crabs to hide under. Small specimens of the blue crab (*Callinectes*), the rock crab (*Cancer*), and the spider crab (*Libinia*) are well worth studying. These crabs are all voracious eaters and may be fed pieces of raw fish, beef, clam, oyster, shrimp, etc.

Suggestions for the care of *Uca* and *Pagurus* are offered in the following sections.

FIDDLER CRAB. *(Uca sp.)*

Fiddler crabs live very well in small marine aquaria and may be kept with other salt-water forms in a five- or six-gallon (or larger) marine tank. However, they like to come out of the water occasionally and, if they are to be kept for study over a period of several months, it is well to provide them with a special tank. This should have a sloping mound of sand and rocks extending above water level at one end of the tank, and natural or synthetic sea-water four or five inches deep at the other end of the tank.

Fiddlers are voracious feeders and should be fed three or four times each week. They will accept raw oysters, clams, fish, or meat. When no other food is available, canned shrimps will prove entirely satisfactory.

Care upon arrival. We usually ship fiddler crabs "damp pack" (without water), but with some of the damp sand or earth in which they naturally burrow. In setting up their tank, use natural or synthetic sea-water—never use fresh water. If the shipment is very cold upon arrival, allow it to warm up gradually before placing the crabs in the aquarium tank.

HERMIT CRAB. *(Pagurus sp.)*

The hermit crab has become specialized so that it must inhabit the empty shell of a marine snail. As it grows, the crab is forced to vacate one shell for another of larger size and this periodical moving from house to house continues until *Pagurus* has attained its adult size. Therefore, if hermit crabs are to be kept for very long, their tank should contain a suitable assortment of empty snail shells of various sizes.

Hermit crabs are quite hardy and will survive for some time out of water. If they are to be studied at length, however, they must be kept in sea-water. They are interesting inhabitants for a small marine aquarium and may also be kept in shallow tanks containing a mound of sand at one end and natural or synthetic sea-water at the other.

Hermit crabs should be fed once or twice a week. Give them small pieces of raw oysters, clams, fish or beef, and, after an hour or so, remove from the tank any food which has not been consumed.

(Note: Refer to section on *Marine Aquaria* for additional suggestions on maintaining various species of marine crabs.)

MYRIAPODA

CENTIPEDES. *(Scolopendra, Lithobius* **and others)**

Centipedes are found under stones, logs and bark in moist places. Sometimes many will be found in or under a large rotten log. They may be kept in a battery jar or terrarium containing a mixture of humus, leaf mold, and well rotted wood, with some pieces of bark or some flat stones on the surface, under which the centipede may hide. Cover the jar or terrarium with wire screening and keep it away from strong light. Feed them living earthworms, mealworms, roaches, slugs and soft-bodied insects. Use care in handling centipedes, for their bite is painful.

MILLIPEDES. *(Spirobolus, Julus* **and others)**

The type of jar or terrarium suggested for centipedes is equally suitable for millipedes. They are sluggish animals, preferring dark, damp places; they feed upon decaying vegetable matter. Millipedes are harmless and may be handled freely. They give off a protective secretion in small amounts which causes animals that would otherwise prey upon them to leave them alone. In the ordinary sense of the word this is unharmful to man since in handling them he is not apt to encounter this in any quantity.

Your inquiries . . .

will be welcomed by the Turtox Service Department. Feel free at all times to ask us for special information concerning the care of living specimens not discussed in this booklet.

ARACHNIDA

HORSESHOE CRAB. *(Limulus polyphemus)*

The king crab, or horse-shoe crab, is easily collected and will live for some time out of water. Small specimens (2 to 4 inches) live nicely and for long periods of time in a marine aquarium, where they spend much of their time partly buried in the bottom sand. Feed them pieces of raw fish, clam or oyster.

SCORPIONS. *(Centrurus, Mastigoproctus* **and others)**

These interesting arachnids are found for the most part in warm regions and prefer rather dry and sandy habitats. They are active at night and remain concealed under stones during the day.

Scorpions may be kept in a large battery jar or a terrarium cage containing a layer of sand (1 or 2 inches deep) and a few stones arranged to afford hiding places. Since the scorpions shun bright light, their terrarium should be kept in a semi-dark location, so that they will not have too great a tendency to hide under the stones throughout the day. Normal room temperature (70° F.) is satisfactory, and sprinkling the sand once a week will provide sufficient moisture for their needs. Living food such as mealworms, roaches, spiders, etc. should be provided. Handle scorpions with great care, as their sting is very painful and even dangerous in the case of large specimens.

SPIDERS.

Most of the spiders found in the United States are quite harmless and many are extremely interesting for laboratory study. The black widow spider *(Latrodectus mactans)* is poisonous and, like the tarantula and trap-door spider *(Ctenisa)*, should be handled with care. However, most of the common species do little harm and the common garden spiders *(Argiope, Nephila,* etc.) are very beneficial animals.

Spiders which spin webs for the capture of their insect prey may be placed in any well-planted terrarium. Some species will live for only a few weeks during the autumn, but others may thrive for many months in a warm terrarium. Feed them living insects.

Burrowing spiders are best maintained in special cages. A satisfactory cage consists of a large battery jar (about 8 inches in diameter and 12 to 15 inches deep), containing 8 inches of light soil. The soil should be quite dry on the surface, but moist (not wet) at the bottom. Cover the battery jar with a wire screen or a loose-fitting piece of glass. Burrowing spiders placed in such a cage will construct their tunnels or burrows, remaining in them most of the time except when they emerge for food. They may be fed upon living insects (during the winter, cockroaches and mealworms are acceptable) and they will sometimes eat earthworms.

Spider Cocoons.

Cocoons of the harmless garden spiders may be found in the late summer and autumn attached to grass and weed stalks. *Argiope aurantia* constructs a brownish cocoon with a slight bottle-neck at the top, where it is attached to low vegetation by silken strands. *Argiope trifasciata* makes a much whiter cocoon which is generally hemispherical in shape. Open and dissect a few of the cocoons. Place the others in a warm woodland terrarium. The young spiders are cannibalistic and not many of the dozens which emerge are likely to survive. They may be fed upon living fruit flies (*Drosophila*) or other very small insects. As they grow they will accept house flies, roaches, etc.

WATER MITES. *(Limnochares, Eylais* and *Hydrachna)*

Water mites are common in most ponds and may be collected at all seasons, although the greatest numbers occur during the late summer and early autumn. In spite of their small size ($\frac{1}{16}$th to $\frac{1}{4}$th inch), they are easily seen because of their bright coloration, which is usually red, scarlet, or orange. They may be collected by sweeping a fine-meshed dip net among thick growths of aquatic vegetation.

Water mites may be kept in a small aquarium covered with fine-meshed screening to prevent their escape. Like other mites, they breathe air, but spend most of their time under water. They are carnivorous, feeding upon small aquatic insects and other forms of minute animal life, from which they suck the soft portions. However, water mites will live for considerable periods without food and will readily accept small snails which are usually present in large numbers in any established aquarium.

INSECTA

PRAYING MANTIS. *(Paratenodera sinensis)*

The praying mantis might well be called the *preying* mantis, for it has a most robust appetite and is aggressive in capturing its prey. Adult specimens (obtainable during the late summer) will live for a considerable time in laboratory cages if they are provided with plenty of living insects upon which to feed. However, during the autumn and winter, living adults are not obtainable and the young may be reared under laboratory conditions.

The Egg Case. Each ootheca of the mantis is a many-chambered egg case or cocoon, containing a large number of eggs which will hatch when the egg case is kept for a few weeks in a warm room. It is well to place the ootheca in a cage or terrarium containing some twigs, grass or growing plants on which the young mantes can climb. The cage may be any kind of a glass jar or terrarium tank which can be kept covered with cheese-cloth or fine-meshed wire screening. Being carnivorous, the mantes do not require fresh vegetation; but the presence of growing plants maintains a natural humidity which is desirable.

Care of the Young Mantis. After the eggs are placed in the cage, it should be kept in a warm location until the young begin to emerge; and then be moved to a part of the room that does not get any direct sunlight. This precaution is necessary to prevent the rapid drying of the casts which are left by the mantes when they moult. If moulting occurs in a dry room or in direct sunlight, the cast may become dry before it is entirely shed, causing the death of the animal.

The young mantes are not only carnivorous, but are also cannibalistic. They have enormous appetites and, if not given plenty of food, will eat each other until only one remains. Their natural food is living insects. *Drosophila* (fruit flies) are an excellent food to begin with, and the older mantes will eat cockroaches and grasshoppers. If living insects are not available, fresh liver may be substituted. Small bits of liver placed on the end of a toothpick and held before a mantis will be devoured quickly.

The moulting process is extremely interesting and illustrates gradual metamorphosis in insects. If a mantis becomes entangled in the cast skin when moulting, it is often possible to assist it by using a pair of forceps and gently drawing the skin away from the animal. Difficulty in moulting will be largely eliminated, however, if the cage is placed where it receives no direct sunlight or drafts and if a natural humidity is maintained.

WALKING-STICK. *(Diapheromera sp.)*

Living walking-sticks may be collected and brought to the laboratory for study, but they are usually obtainable only during the late summer. Most teachers find it more convenient to secure eggs and allow these to develop and hatch in an insect cage. Eggs of the walking-stick insect may be collected during the late summer or early fall, and Turtox regularly supplies them from about the middle of September to the last of March. Eggs intended for laboratory hatching are usually stored at a low temperature to retard development, but the young walking-sticks will emerge within a few weeks after the eggs are placed in a warm room.

Care of the Young Walking-sticks. The young require fresh vegetation for food as soon as they emerge from the eggs, and, during the winter, it is well to plan ahead on this requirement. The following plan is suggested: (1) Provide a glass cage (a battery jar will do) with a cheese-cloth or wire screen cover. (2) Place about two inches of sandy soil in this container and sow grass and white clover seed rather thickly in it. (3) Keep in a warm place and, if possible, in direct sunlight. Keep moist so seeds will sprout. (4) When the grass has started to grow, place the walking-stick eggs in the cage. (5) The young walking-sticks will eat the grass and clover leaves. Care must be taken to prevent excessive moisture from gathering on the sides of the cage (jar) and on the vegetation while the walking-sticks are still very small.

They will develop quite rapidly if provided with sufficient plant food, their method of growth demonstrating gradual metamorphosis in insects. When larger, they may be transferred to a well planted terrarium and given locust leaves, lettuce, celery tops and other vegetable food.

COCKROACHES. *(Blatella, Blaberus* **and others)**

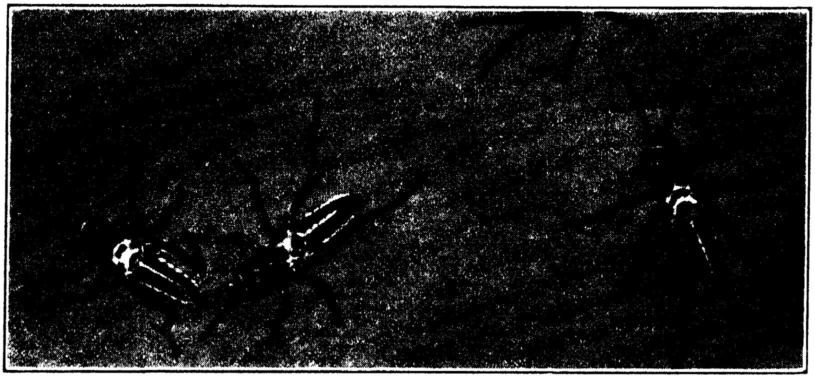
Living roaches form an excellent food for many laboratory animals, especially during the winter months when other living insects are not readily obtainable. They also furnish interesting demonstration material of incomplete metamorphosis. It is, of course, important that care be exercised in culturing them and that they do not escape to infest the school laboratory.

The Common Cockroach, *Blatella germanica*

There are many slightly different methods one may use in propagating the croton bug, or common roach. Because of its simplicity, we recommend an ordinary gallon jar (the top of which is covered over with cheese-cloth held in place by a rubber band about the rim) as being an entirely suitable culture receptacle. In the bottom there should be a covering of sawdust, about ½ inch deep and a shallow dish for water. The dish may be filled with a sponge or cotton to prevent the roaches from drowning. A thin line of vaseline is placed around the inner surface of the shoulder of the culture jar and the cockroaches will not attempt to crawl out over it. A shallow food receptacle should be placed on the sawdust.

Cockroaches are frequently described as "omnivorous" and one certainly believes this when he glances at a list of articles which they actually relish. A mixture of bread, cornstarch, and water with bits of lettuce or spinach makes a good food. They also thrive upon sliced potato, mashed banana, some milk and library paste. Keep an abundant water supply before them at all times.

Special mention should be made of a method we have recently been using in our Live Materials Laboratory. A one-gallon jar is equipped as mentioned above except that no sawdust is used. The entire bottom is covered over to a depth of ¾ inch with the medium used for culturing *Drosophila,* but it is made up drier. The roaches are placed in this and a thriving colony can be kept here with a minimum of trouble. Reduce the amount of evaporation by placing a glass plate over most of the opening which is first covered with cheese-cloth. The insects will gradually eat up most of the medium and may be transferred to other jars after anesthetization with ether. A temperature of 70° F. or slightly higher is desirable.



Recently hatched nymphs of the lubber grasshopper (Romalea) on the glass side of a terrarium. These grasshoppers are easy to rear during the winter months.

Blaberus craniifer

The large, black tropical roaches from southern Florida and Key West are interesting in any biology laboratory. *Blaberus* is not the omnivorous feeder that *Blatella* is, but will accept several of the foods mentioned above for the latter. Dried bread crusts soaked in sugar water are relished, as are also mashed banana and lettuce. Keep plenty of water available.

The bottom of the culture box should be covered to a depth of an inch with fairly coarse shavings. Keep the temperature high—75° -80° F. being preferable. When kept cool, the animals become sluggish and do not take food regularly, with the result that they soon die.

GRASSHOPPERS

In most sections of the United States, it is a simple matter to collect living grasshoppers during the late summer and early autumn months. Adults are usually plentiful by August, although nymphal stages of some species may be found in the field as late as September in the latitude of Chicago.

A grasshopper cage should be fairly large (18″x24″x12″ is a good size) and may consist of a wooden framework covered with wire screening. Or a rectangular aquarium tank with a screen cover may be used. In either case, some earth or sod should cover the bottom of the cage and this should be kept moist (not too wet) at all times. Plants and branches bearing plenty of leaves should be placed in the cage to provide food, and fresh leaves should be provided daily. A sweet mash of bran, oatmeal, and molasses may also be used as a food for large grasshoppers.

Lubber Grasshopper. *(Romalea microptera)*

Like other grasshoppers, *Romalea* lays its eggs in the soil where they normally remain during the winter and until the young nymphs emerge the following spring. The living eggs which we supply are laid in natural earth in large laboratory cages and are available throughout the autumn and winter months. If maintained at average room temperature (60° to 70°), the eggs hatch about the middle of February; lower temperature retards their development, of course, and refrigerated eggs may be held over fo: hatching in the late spring.

Rearing Cage. We ship the eggs in a small container of damp earth. When received, they should be removed from this container and buried under about an inch of earth in the rearing cage. Almost any type of container which allows for a circulation of air will suffice as a rearing cage; a gallon-size aquarium tank, a large battery jar, a screened terrarium or the Turtox Junior Vivarium will do. The container must be covered with cheese-cloth or fine-meshed screening.

The bottom of the rearing cage should be covered with about two inches of soil and the eggs placed in this. If a glass container is used, the eggs should be planted near the glass sides in order that the emergence of the embryos can be observed. After placing the eggs in the soil, pack it down firmly and sprinkle with water. The soil must be kept moist (not wet) at all times, since lack of sufficient moisture will dry out the egg yolk and kill the embryo. It is advisable to sow grass seed in the rearing cage. The growing grass will help maintain natural moisture and will furnish food for the emerging nymphs. If the eggs are kept at room temperature, the nymphs will emerge in February. Eggs may be opened at earlier dates for examination of the developing embryos.

Care of the Nymphs. The nymphs will begin to eat about twelve hours after they emerge from the eggs. They will accept almost any kind of vegetable food. A lettuce leaf may be placed in the cage daily and that left over from previous feeding removed. Slices of apple can also be added for food. Moisture can be provided by dipping the food in water before placing it in the cage. After the nymphs emerge, keep the cage fairly dry and provide them with twigs or other supports to climb upon.

Study Suggestion. Observe the color of the newly emerged nymphs and their color a day or so later. Note their rate of growth and the number of moults. Test their reactions to various kinds of food.

CRICKETS. *(Gryllus sp.)*

Crickets are easily kept in laboratory cages for considerable periods of time and are interesting insects to study. Because they are cannibalistic under some conditions, it is unwise to place too many in a small cage, but two or three will live in a small battery jar (or even in a quart mason jar) having an inch or so of damp sand in the bottom. Larger numbers may be maintained and conveniently studied in the Turtox Observation Ant Home.

Crickets accept both animal and vegetable food, eating bread, apples, lettuce, meat scraps, dead insects, etc. They are especially fond of peanut butter.

MEALWORMS. *(Tenebrio molitor)*

Mealworms are one of the most widely used living foods for many of the laboratory animals, particularly lizards, snakes, toads, frogs and salamanders. Birds also relish them and they are readily acceptable to small turtles and the larger aquarium fishes.

Mealworms are the larvae of the black beetle, *Tenebrio molitor,* commonly found in grain bins. If purchased from a supply house, the mealworms come to you in a small box or carton in which there is considerable bran. Save all of this, as it has been taken from a stock culture and is apt to contain eggs and minute larvae that are scarcely visible.

Culture Methods. The size of culture you wish to maintain determines the size of receptacle in which to house it. If a moderate culture only is required, then use a jar of about ½ gallon capacity—a Mason jar is suitable, as is either an Amerseal or a crock. Clear glass jars should be wrapped with black paper. Punch a few small holes in the lid or cover the top with fine screen. Fill the jar about half full of ordinary bran—the breakfast food will do. Add dry bread crusts and crush a sheet of newspaper and insert this. Place a carrot or a half of an apple in about the center as this supplies some moisture and also serves as food. Now, empty the contents of the package you've purchased directly into the culture jar.

Very little further care is necessary. Add a crust of bread occasionally and a carrot or apple as the other becomes dry or is consumed. Keep the jar in a warm location, particularly in winter. Optimum temperature is about 85° F. Even at a high temperature, the life cycle is long—four to six months—and, if the culture is cool, development is greatly retarded. Teachers usually take advantage of the warm summer months by establishing cultures that will have developed greatly over the vacation period and thus be ready to draw upon in the fall and winter months. Subdivide whenever the culture will permit, never throwing away the old food as it

Left: A mealworm culture. Adults, larvae and pupae are shown.

contains the eggs and larvae. Adults appear as black beetles, crawl about over the surface of the bran for a few days, mate, lay eggs, then die.

Some workers have success in using chick-growing mash as food for the culture, keeping it in large screened boxes and adding moisture to overlying burlap covers. Others use the same set-up for large cultures; but with bran as the food. Care must be exercised in either method to prevent excessive moisture, molds, and fermentations.

ANT-LION. *(Myrmeleon sp.)*

The ant-lion (or "doodle-bug" as it is often called) is the larval form of the neuropteran *Myrmeleon.* It is unique in that it constructs a small sand trap in which to capture its prey. The familiar trap is to be found in many sandy regions, about the bases of trees, under overhanging projections and under porches. Usually, traps are found where they remain perfectly dry, for when wet the larva cannot obtain its food—must go hungry until the walls of its uncanny trap will again crumble beneath the weight of an ant or other small wingless insect.

In the culture set sold by Turtox are the essential items for the care of the ant-lion—except living food. These are: a small glass jar, enough *dry* sand to cover the bottom to a depth of about an inch and the living larva. As soon as the set has been received, look through the sand in which the larva can be found. Be sure to examine it carefully while it is exposed, for you will actually *see* but little of it later. Place the larva upon the sand in the jar. Within but a few hours, it will have constructed its funnel-shaped trap, where it will lie with but the mandibles showing at the very bottom.

After the trap has been formed, drop *one* ant (not over ¼ of an inch long) into it. The capture of it is an exciting process. If ants are not available, small sow bugs, flies (with wings clipped), and similar forms may be used. The larva will get along all right if fed only about once a week—will remain a larva longer. However, it may take repeated feedings, one right after the other, if you wish it to become an adult sooner. Eventually, the larva will construct a cocoon in the sand and finally emerge as a graceful four-winged "fly," not greatly unlike a damselfly.

Keep jar at room temperature. Lid must be on when adult is to emerge—then but loosely. Keep in a quiet place. *Never* add water to the sand—it does not require it.

BUTTERFLIES

During the early fall months, one may collect chrysalids of various butterflies from their attachments on food plants and objects near them. These, when brought into the laboratory, will almost always yield beautiful adults within a relatively short time, if cared for according to the suggestions given below. Turtox also maintains a good stock of butterfly pupae from October until after the first part of the succeeding year. Various species of *Papilio* are always on hand and frequently pupae of other forms can be sent—there being some variation in collecting these forms from year to year.

A screened box makes a suitable rearing cage if a more elaborate, specially constructed metal rearing cage is not available. One must be sure to add strips of moist paper towels to such a cage so as to keep the air in the cage as moist as would be the case out-of-doors. There must be ample ventilation in such a cage also.

An old aquarium tank with screen cover makes a good rearing cage. Cover the bottom with two inches of soil and then, after gluing the chrysalids to twigs, they may be inserted into the soil. Keep the soil damp at all times, but never dripping wet.

If one wishes to delay emergence, he may keep the pupae in a cold room or in a properly humidified refrigerator. When kept at ordinary room temperature, emergence will take place usually in January or February. Don't throw away any which have not emerged by this time as they may simply become adult more slowly.

Further suggestions applicable to butterflies are given in the section on *Large Moths.* Food plants suitable for the larvae of various species of butterflies may be determined by reference to any good entomological book.

SILKWORM MOTH. *(Bombyx mori.)*

Perhaps the first matter that should be mentioned is that *Bombyx mori,* the common silkworm, does not pass the winter in the cocoon stage, as do so many of our common silk-weaving moths, but lives over the winter in the egg stage only. Most teachers know the large silken shells in which pupae of *Cecropia, Polyphemus, Luna, Io,* etc. pass the cold winter months; but they are less familiar with the egg form of these moths. The fact that the silkworm passes the winter in the egg stage determines largely the rearing methods which must be employed if its complete life history is to be observed during the school months.

Commercial growers of silkworms keep large quantities of eggs over winter in cold storage. The development of these eggs can be postponed almost indefinitely if they are kept at a low temperature. This means, also, that eggs may be allowed to hatch at almost any season of the year if they are removed to summer temperatures. The rearing of the silkworm is practical only during the spring months in most schools, for it is only at that time of the year that food is plentiful. The silkworm is widely famed as an eater of mulberry leaves and can be reared successfully also on the leaves of the osage-orange. Without regard to which tree is to supply the food, however, it is essential that the spring season shall have advanced to a point where fairly large axillary leaves are available before the eggs are allowed to hatch. The newly hatched silkworm larvae do not live well if fed the very young and juicy leaves which have just unfolded; they should have leaves which have begun to grow. It has also been determined that the young larvae will relish and grow fairly well if fed young buds of the mulberry tree. Each bud must be split in half with a knife or scalpel before it is fed to the worms.

These buds may, of course, be collected during the winter months, the twigs being placed in vases of water and kept in a warm room until the buds begin to swell. They may then be split and used as food for the young worms. (It should also be mentioned that the young worms will feed upon such substitutes as lettuce or celery leaves, but they will not grow to maturity on these foods. Apparently, the leaves of mulberry or osage-orange are required if the worms are to grow to full size and pupate. Substitute foods may be used if, during the winter, the teacher wishes to demonstrate merely the hatching of the eggs and the feeding of the young worms.)

Varying with the latitude, the eggs can be allowed to hatch in March, April, or May, or whenever the food leaves are ready. After this, all that is necessary, in the schoolroom at least, is to keep the larvae confined to a screen-enclosed box well supplied with fresh food. The development proceeds as follows, the variations indicated being due to local conditions in the air temperature, for insect development always proceeds more rapidly on warm days than on cool:

Schedule of Developing Time

1. *Eggs.* The eggs hatch in from 7 to 10 days after being removed from the ice box.
2. *Larvae.* The larvae feed for from 30 to 40 days and then pupate.
3. *Pupae.* The pupal period lasts for about 2 weeks, when the adults emerge.
4. *Adult.* Within a few days of emergence, the eggs are laid and the adults die.

It will be seen from the above schedule that the period of development of the silkworm moth lasts for from six to eight weeks. This just about allows for complete development in the latitude of Chicago before the close of school in the spring.

The living eggs are procurable at all times throughout the year and, by "forcing" mulberry or osage-orange leaves during the late fall or winter, it is possible to rear the larvae and have this moth complete its life cycle during the school year.

LARGE MOTHS. *(Samia cecropia, Telea polyphemus* **and others)**

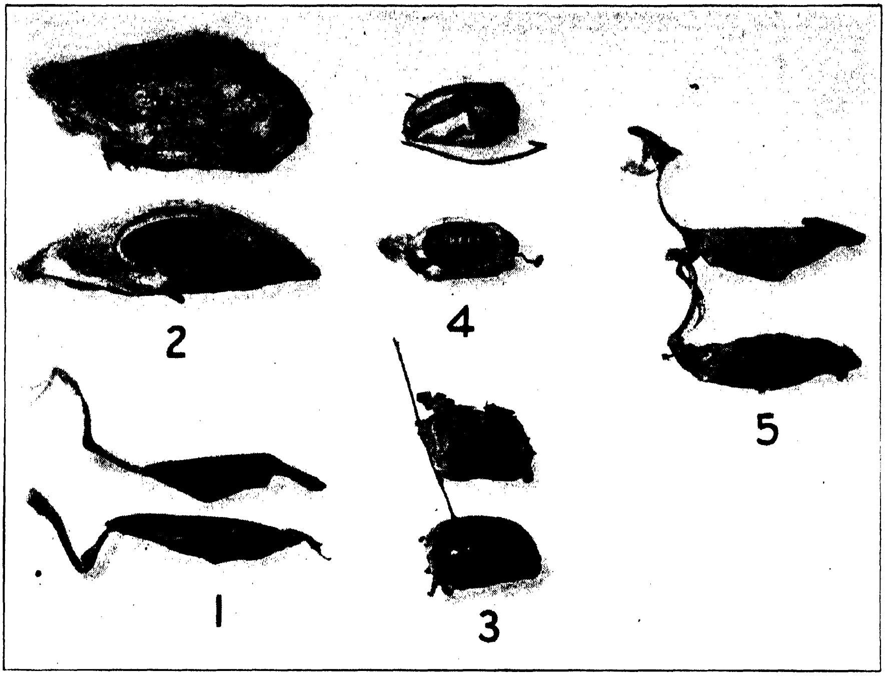
The larger night-flying moths usually studied in school laboratories include the Luna, Polyphemus, Promethea, Cynthia, and Cecropia. These species are fairly common and, during June and July, the adults are often attracted to lights and are easily captured. During the autumn, the cocoons may be collected or purchased.

Care of the Cocoons. Cocoons may be found in the autumn or winter attached to twigs or weed stalks, or they may be purchased from dealers any time between October and April. If you wish the adults to emerge during January or February, the cocoons should be brought into a warm room during October or November. In general, the adult moths will emerge in from sixty to ninety days after the cocoons are placed in a warm location.

A suitable storage and emergence cage is a screened wooden box in which a number of twigs and small branches have been placed. A layer of Sphagnum moss may be placed in the bottom simply to absorb water which is periodically sprinkled over the cocoons; about once a week is sufficient. The Sphagnum dries gradually and thus a fairly high humidity is retained in the cage for several days. One should not keep the container so moist as to cause mold to develop. On the other hand, the proper regulation of moisture is essential if perfect specimens are to emerge. The air in heated rooms is usually very dry and has a marked detrimental effect upon the pupae in the cocoons if they are not wetted occasionally. The most common defect is crumpled or vestigial wings.

The practice of gluing the cocoons to small branches and "planting" them in a layer of humus (kept damp) in a terrarium tank with screen cover is seen frequently and is to be recommended. Some even place a thin layer of Sphagnum over the earth in a flower pot in which a plant is growing and place the cocoons upon this. Each time the plant is watered, the cocoons are moistened. One must be careful to see that no mold develops if he uses this method. Then too, upon emergence the adults may fly about the room and either die unnoticed or ruin their wings trying to get out of a window. We mention these methods to show that several set-ups are possible and will give success.

After the moths have emerged and their wings have dried, they may be killed for the insect collection. Large cyanide jars may be used or a small amount of carbon tetrachloride may be



MOTH COCOONS . . . (1) Callosamia promethea, (2) Samia cecropia, (3) Actias luna, (4) Telea polyphemus, and (5) Philosamia cynthia.

poured onto the ventral side of the abdomen as the insect is held firmly by the underside of the body.

The incidence of parasitism by Ichneumon flies among cocoons of Cecropia and Polyphemus runs high in nature. Turtox sorts over all of its cocoons carefully, discarding all showing any evidence of parasitism. All of our cocoons are guaranteed to emerge if cared for by the methods suggested above.

Rearing Adult Moths. Adults which emerge from cocoons during the winter will not live for very long. They may breed and lay fertile eggs, but, even though these eggs hatch, the young larvae seldom survive because their food plants are not available during the winter months.

If you wish to rear the larvae, arrange to have adults emerge from the cocoons during June, when the required plant foods are available. They will breed and lay eggs in a large screened cage and the eggs will hatch within a week or so. As soon as they hatch, the larvae must be provided with food and this will be needed in increasing quantities as they grow and increase in size. Acceptable food (leaves) for the common moths are:

Callosamia promethea—Wild cherry, ash, lilac.
Samia cecropia—Willow, maple, apple.
Telea polyphemus—Willow, apple, plum, basswood.
Philosamia cynthia—Ailanthus, lilac.
Actias luna—Hickory, walnut.

The food plants should be placed in jars of damp sand (to prevent the leaves from wilting) and a fresh supply should be placed in the cage each day. On reaching maximal larval size, the larvae will pupate (during the late summer) and spin cocoons.

CLOTHES MOTH. *(Tineola bisellliella)*

Clothes moths are familiar household pests, the larvae of which cause considerable damage to woolen fabrics, fur, hair, and feathers. If the temperature is favorable, the life cycle is completed in a very short time. They prefer darkness and are found in closets and poorly lighted rooms.

Cultures are best started with eggs, larvae, or pupae, since the adults usually seen flying around have already laid their eggs. A gallon jar or large sealright carton are simple but adequate culture containers. Any glass container used as a culture jar must be covered with dark paper to keep out all light. The culture should be supplied with woolen cloth, felt, or dried animal skins as food. Enough material should be placed in the jar to fill one-third of its volume, which provides sufficient food for six months or more. The culture develops slowly at normal temperature; but growth is rapid in temperatures around 85° to 90°. After a good start, adults, eggs, larvae, and pupae will be found in the culture at all times. Every six months, additional cloth or dried skins should be added. The culture jar should be covered, of course, with fine-meshed screening to prevent the escape of the adults.

HONEY BEE. *(Apis mellifica)*

Many schools are now equipped with observation bee hives in which all of the activities of the bees may be seen and studied at close range. Various types of observation hives may be purchased or constructed and, if desired, the bees can be secured from local apiaries. However, it is usually more convenient and just as economical to purchase an observation hive, containing the bees, all ready to install on your window sill. Turtox supplies such a hive and will gladly furnish details upon request.

Even in the Northern states the bees remain quite active and feed throughout the winter months. On mild days (whenever the temperature goes above 50° F.) they leave the hive for short trips out doors, and when the first spring flowers appear they are fully active.

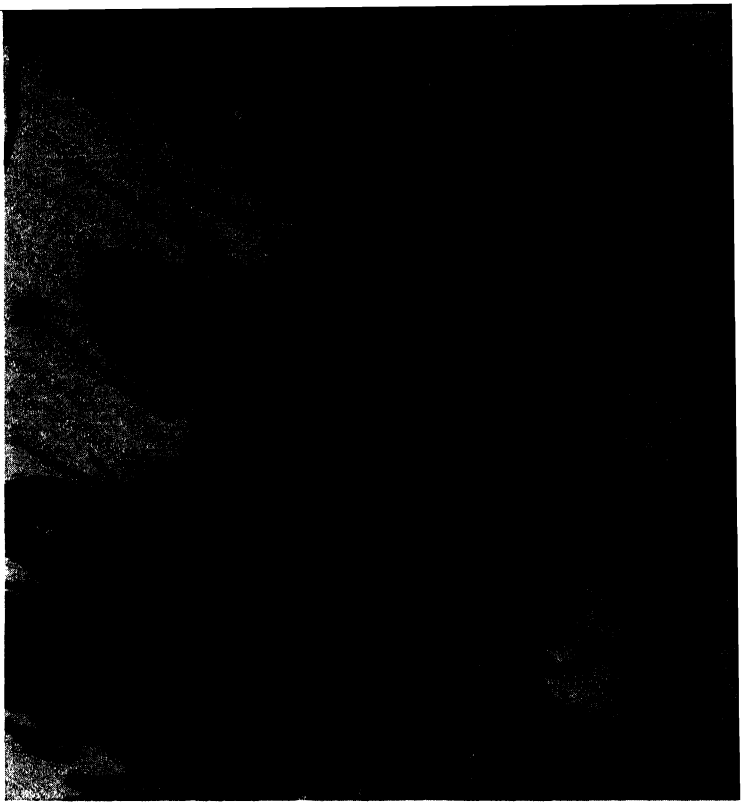
ANTS

There are dozens of common species of ants which can be kept successfully in laboratory observation nests. Their habits differ slightly so that conditions suitable for one species may not be exactly optimum for another—however, by slight modifications these different requirements can be met satisfactorily. Ants are plastic creatures; they are able to adjust themselves to an altered environment quite readily. One need not, therefore, duplicate exactly the natural setting in the laboratory in order for the ants to live perfectly satisfactorily. We emphasize this point for so many teachers who have not had experience with "dirtless" observation nests, think them too unnatural and that the ants can not live as well as in their natural state. Quite the opposite is true; just as long as there is a proper amount of humidity in the nest atmosphere, as the temperature is kept in the desirable range, as the proper food is available and as long as a state of cleanliness is maintained, that long, one may expect the colony to live and behave normally. All of the time there is the great advantage of having all members of the colony—even the brood—available for close and instant study.

Where to Collect

The mound-building ants are to be found in open prairies, along ditch banks and even bordering swampy areas. One of the most abundant in the Chicago region is *Formica neocinerea.* The mounds of this form are usually about a foot in diameter and ten inches high, although these dimensions vary widely—some mounds are over thirty-six inches in diameter! When the mound is located it is easy to dig into one side of it with a spade and to obtain the ants, mixed with the earth. If you are fortunate a queen may be located. Transfer the collection immediately to a wide-mouth bottle. Carefully replace the disturbed soil to its former location in the mound—never leave an unsightly excavation behind you.

Another common species of ant in the Chicago region is *Myrmica scabrinodis* and it is a good form for laboratory study. It inhabits small earth craters often surmounted by little "chimneys" of closely knit grass blades, small sticks and earth pellets. This ant usually lives in small colonies—two or three hundred workers with one or more queens—and thus it is possible



Right: Living worker ants photographed in a Turtox Observation Ant Nest.

to remove the entire colony for nest observations. It is a desirable form during the winter especially since larvae are usually present.

Types of Observation Nests

Ants can be kept in jars filled with earth for a surprisingly long time but this method would be recommended only when all others are impossible. For most of our earth-dwelling forms, the wooden ant nest with the sliding glass covers is quite satisfactory. Ants which excavate their galleries in wood (for example, our carpenter ants) would hardly be suitable to this type of nest although colonies have been maintained in it successfully. This nest requires almost daily attention if one wishes to keep it functioning satisfactorily, but any laboratory colony of ants needs a daily inspection, at least. In this nest, one does not have the facility of being able to work with the ants in the open—but if he is patient and has due regard for the senses of the ants, he can accomplish much in the way of handling the colony while it is securely encased.

In striving to improve upon demonstration ant nests, Turtox designed a plaster of Paris type which is practically ideal from the laboratory standpoint. The nest proper has been cast in the form of a miniature modernistic apartment, the "roof" of which is countersunk to provide two compartments which when covered over with glass make ideal living quarters for the ants. This building is then set into a "yard" constructed of heavy paper-covered cardboard, around the outer edges of which is a loose dry plaster of Paris barricade. The compartments for the ants are kept moist by the addition of water every day or two. The openings from the compartments to the exterior of the building are plugged with cotton for three or four days—long enough for the nest to absorb the odor or "aura" of the colony. The ants are then given their freedom, range all over the nest and the "yard" up to the barricade. By keeping one compartment covered with a colored glass most of the ants will concentrate in it. The queen and developmental forms will be kept there all of the time. By shifting the glass to the other compartment the entire colony will move of its own accord although this may require several hours.

Feeding in the above type of nest is least troublesome and it becomes an easy matter to keep the compartments perfectly clean. No food is ever placed in the nest, the ants are fed on the outside but will, of course, take some of the food into the nest for consumption. This type of nest has proved very popular even in the short time it has been available. The ants lead an interesting life in it.

Transfer to Nests

If ants have been collected with a considerable amount of dirt, it is possible to have them transfer themselves to a prepared nest. A large table area, two or three feet square, is enclosed with a loose plaster of Paris barricade, smoothed on the inner surface to prevent the ants from escaping. The nest, properly prepared with sponge for moisture, food, etc., is placed in the area. The jar containing the earth and ants is emptied in the area also. As the dirt dries out, the ants will gradually forsake it in preference to the better conditions in the nest compartments.

If the ants are purchased and are free of earth, it is possible to cool them in a refrigerator until they are so sluggish that hardly a leg movement can be seen and then to dump them quickly into the prepared nest. Their recovery is almost immediate so that this transfer has to be effected without delay. The near-freezing temperature does them no particular harm but it is fatal to the majority to freeze them rapidly and then place them in a warm nest. Ether can be used on some species; is highly detrimental to others. Its effects are longer lasting in any case. Only a person experienced in its use with delicate insects should employ it.

Food

Most people feed too much. It is far better to feed in minute amounts and to feed often. Sugar water, about half sugar and half water, is relished by many species—certainly by the two mentioned specifically above. Freshly killed insects such as flies, crickets, soft-bodied caterpillars and mealworms should be given them frequently—the ants can subsist upon them entirely. A mixture of honey, butter and white of egg in about equal amounts is a good nourishing food. Small bits of fresh apple, and grape are taken by many ants.

For an ordinary colony of some two to three hundred ants two droplets the size of a "BB" shot fed daily would be ample. Or, feed more at a time and not so often. Gauge the feedings by the amount cleaned up in about ten minutes.

Important Rules

Keep the nest where it will not be jarred unnecessarily. The ants are unusually susceptible to nest vibrations. Provide one semi-darkened compartment at all times and it may be darkened completely when not under observation. One nest compartment must be kept moist or a saturated sponge be within it. Feed sparingly of liquid foods—do not allow an excess to get into the nest, lest a prolific growth of molds develop. Do not place dirt in the observation nests described here—the ants will get along better without it. Never mix colonies unless they are known to have come from the same earth mound. It is not desirable to have sunlight fall upon the nest; it is better to keep it away from the window.

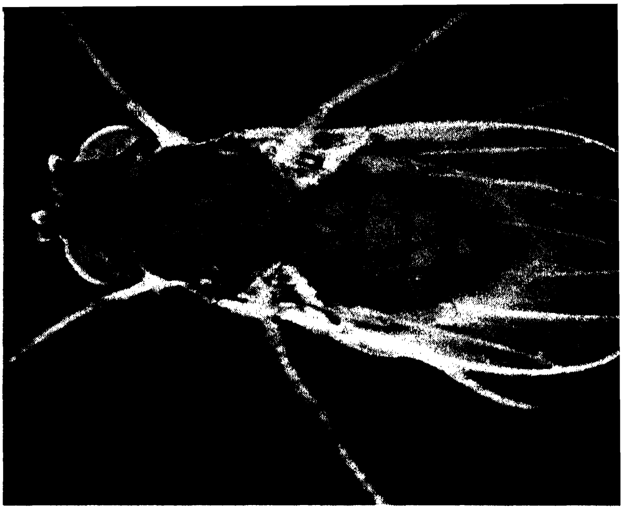
The ant colony should be a never-ending source of interest for students of all grade levels. Give it the patient care and observation it merits and it is easily possible for it to be kept going for years.

BLOW FLY. *(Lucilia sp.)*

The culturing of blow flies in the laboratory is not difficult and the time required to complete their life cycle is comparatively short, from twelve to fifteen days. The culture develop rapidly at normal room temperature.

Adult and developing stages of blow flies are commonly found around carrion and garbag dumps. The culture may be developed in various types of containers, a small screen cage being satisfactory. In it are placed a simple drinking fountain, made by inverting a small tumbler of water on a half circle of filter paper in a petri dish, and a small quantity of sugar for food. Every

Right: The fruit fly, Drosophila melanogaster.



two days, strips of lean meat or liver are placed in the container as food for the adults and upon these the eggs are laid. The meat is left in the cage only a few hours. It should be moist and, if it dries out, must be removed. The adult flies lay eggs three to six days after eating meat. After the eggs are laid, they are removed with the meat to the pupation jar, a gallon jar half filled with moist sand and kept covered with cheese cloth. In three or four days, the larvae complete their growth and crawl into the sand to pupate. Pupation is completed within a few days and flies will emerge from the pupae four to five days later.

Aside from their usefulness in teaching, the larvae, pupae, and adults can be used as food for aquarium and terrarium animals such as fish, lizards, salamanders, and frogs.. Excess larvae can be kept without food for a few days in a refrigerator, while the pupae live for longer periods under similar conditions.

There is a variation of the method just described which is equally good. After the eggs are laid, they are removed from the meat and placed in test tubes in which have been placed small pieces of fresh meat or liver. The test tubes are plugged with snug-fitting cotton stoppers which prevent the young larvae from crawling out. Fifty to seventy-five eggs are enough for each test tube. When the larvae are nearly full grown, in three or four days, the test tubes are placed in the pupation jar. As the larvae are ready to pupate they crawl out of the tube into the sand.

FRUIT FLIES. *(Drosophila melanogaster)*

Drosophila melanogaster has attained prominence in the field of genetics because with this form it is easy to demonstrate the principles of heredity, such as the Mendelian ratio, sex linkage, dominance and variation. The life cycle is completed within ten days and, consequently, many generations of flies are produced in a relatively short period, which is a helpful factor when breeding for pure strains of specific mutations.

Much has been accomplished in methods of culturing Drosophila. A culture of wild Drosophila can be started by allowing a dish containing some ripe banana to stand open. The food draws the flies, which lay their eggs on the banana. This culture can be continued by transferring the larvae and pupae to other banana cultures. The use of this medium dates back to the beginning of the study of Drosophila. However, superior culture methods have replaced the banana cultures.

Media. The medium that we suggest is one recommended by Dr. C. B. Bridges, now of the California Institute of Technology.

40	grams of agar agar
200	grams of corn meal (yellow corn meal may be used)
140	c.c. Karo corn syrup
140	c.c. Bre'r Rabbit molasses
2000	c.c. water

To prevent molds, add 2 grams of *Moldex* to the above formula.

First, add the agar agar to the water and bring it to a boil. At this time, slowly add the corn meal, stirring continuously. When well mixed, add the molasses and allow to boil slowly for ten minutes. Care should be taken not to cook the medium too long, as excessive cooking will cause it to harden in the cooking dish, thus rendering it useless.

As soon as the medium has finished cooking, remove it from the fire and pour it at once into the sterilized bottles. Two inches of medium should be used in a quart size culture bottle and ½ inch is enough for a 2-ounce size bottle.

As soon as the medium has been poured into the bottles, strips of sterile paper toweling cut the length of the bottle and folded double should be inserted into the medium, so that the flies will have a place on which they may crawl to pupate. To avoid contamination by molds, soak the paper toweling in a *Moldex* solution (1.5 gms of Moldex to 5 cc. of 90 per cent alcohol) before inserting in bottles.

Allow this medium to harden and then, just before stocking the bottle with the flies, dissolve a small portion of yeast cake in some water and, using an eye dropper, drop one drop of this liquid into each bottle.

Containers. The flies are usually shipped in 2-ounce bottles and, as soon as they have been received at the school, the adult flies should be transferred to the stock bottles (quart milk bottles containing about 2 inches of medium). Close the bottle with a plug of sterilized absorbent cotton.

Eggs will have been laid in transit and will remain in the shipping bottles after the adult flies have been removed. Care for these and new cultures of adult flies will soon be available.

When flies are to be used for mating, they should be transferred to sterilized wide-mouth bottles of 4 to 6 ounce capacity, each containing one inch of medium.

Sterilization. It is very important that all containers, as well as the cotton plug, paper toweling, ether bottles, and mating bottles, be well sterilized before using. Unless this is done, good results are impossible.

Storage of Cultures. Cultures may be kept on shelves or on a desk in the laboratory; they will do well at average room temperatures. If the room is quite warm, they will develop rapidly, and, if it is cool, it will take a longer period of time for them to complete the life cycle.

Avoiding Contamination of Cultures. It is of utmost importance when working with the Drosophila cultures to take all precaution against contamination. Transferring flies to or from cultures should be done as quickly as possible. Mold spores, which are always floating in the atmosphere, often get into the cultures. The growth of molds in the cultures is very annoying because contamination continues in spite of subculturing unless special precaution is taken. When subcultures are to be made, the pupae, instead of adult flies, should be transferred after they have been washed in a wine-colored solution of potassium permanganate. If the mold is not destroyed with the first treatment, the pupae of the subcultures should be treated until the mold is finally eliminated.

A major factor in keeping Drosophila cultures clean and the strain pure is to start fresh cultures every two or three weeks. Old cultures are more likely to become contaminated with molds.

Distinguishing Males from Females. This requires a bit of practice and should be tried out on the material in the stock bottles before the mated flies begin to appear. The female has a slightly broader abdomen than the male and also has small lines across the tip of the abdomen; while the male, which is smaller, has a black-tipped abdomen.

To Secure Virgin Flies. If accurate results are to be secured, care must be taken to use only virgin females for mating. The best way to secure them is to remove some of the pupae at about the seventh day after mating and place them in separate bottles. This is necessary as the flies will mate within a short time after emergence.

Technique for Examining the Flies. Secure a bottle the same size as the one used for breeding and insert a cork stopper into which a wire has been run. Attach a small wad of cotton to the lower end of the wire and moisten this with a few drops of ether. Shake some flies from the breeding container into the anesthetizing bottle. After the flies have been etherized for a minute, they may be dumped onto a piece of paper, and, with a fine camel's hair brush, sorted into groups of males and females, as well as into groups of the different types of mutations. If the flies are to be used for mating, do not leave them more than a minute in the ether; but, if they are to be counted and recorded in your notes only, they may be killed by being left for several minutes in the ether bottle.

Mating the Flies. Place one male and one female in a bottle, containing the proper amount of medium. Record the date on a slip of paper and paste it on the side of this bottle. Ten days later, after the eggs have been laid, remove the parent flies, so that they will not interfere with the count. In twelve days, the flies should begin to emerge, at which time they should be counted each day for ten days. It is best to make this count as near the same time each day as possible. After three days of counting, some of the most healthy-looking flies should be separated and used for further mating to continue the strain.

(*Note:* Suggested matings are listed in the free Turtox Service Leaflet No. 15.)

In addition to their use in genetics experiments, living fruit flies are valuable as a winter food for tree frogs, small lizards, and other laboratory animals.

MOSQUITO. *(Culex sp.* **and others)**

As is the case with certain flies, adult mosquitoes frequently live during the winter in a semi-dormant condition in cellars and sheds. Several species of mosquitoes breed during the winter in cellars where the temperature is sufficiently high and where open drains or other unsanitary conditions furnish the necessary moisture. During the warmer months, the "wigglers" or mosquito larvae may be found in ditches, pools, rain barrels and in many other places where stagnant water occurs. The larvae and pupae are easily collected with a fine-meshed dip net and may be brought back to the laboratory in jars of water for study or for use in feeding the aquarium fishes. When collecting the larvae and pupae, look also for the eggs which occur in "rafts" and float upon the surface of the water.

A very simple container will suffice for keeping the common mosquito (*Culex*) in the school laboratory. A small aquarium tank or battery jar will do, but it should be covered with cheese-cloth or fine-meshed screening. The container should be about two-thirds full of water with enough space left above the surface of the water so that the adults may have room to fly. The student can then observe the habits and method of feeding and the emergence of the adults. Breeding will take place and eggs will be laid if the adult female mosquito is given a meal of blood; a mouse serves very well for this purpose.

The larvae and pupae of mosquitoes are important as an item of living food for aquarium fishes and for some of the aquatic salamanders.

To illustrate methods of control, a few larvae or pupae may be released in a jar of water and then a small amount of oil may be poured on the surface. The oil film prevents the larvae and pupae from obtaining air and they soon die.

GLASS WORMS. *(Chaoborus* **larvae)**

These transparent aquatic "worms" are really the larvae of *Chaoborus* (formerly *Corethra*), a mosquito which does not suck blood. The larvae occur in ponds and slow streams and live well in a balanced aquarium, where they eventually pupate and then emerge as flying adults. The larvae are carnivorous, feeding upon entomostracans, rotifers, and other small forms.

Glass worms are interesting inhabitants to keep in a small balanced aquarium, but they should not be placed in a tank containing fishes. When obtainable in quantity, they are valuable as a living food for aquarium fishes.

AQUATIC INSECTS

It would be difficult, indeed, to do much general aquatic collecting without encountering various forms of insect life whether or not they be sought. One should not pass up this most interesting group of insects, he should arrange to bring representatives back to the laboratory for a thorough study. If one goes afield for aquatic insects especially, he may expect to find them in ponds and slow-flowing streams where there is a good supply of aquatic vegetation. Do not seek only the adult form—many of the immature stages are to be found in great abundance and their habits may even surpass those of the adult form from the standpoint of general interest.

The dip net is naturally the most essential collecting device. The mesh should not be too coarse lest some of the interesting minute forms pass through it. One who does a great amount of aquatic collecting will wish to have a combination of two nets, one with a coarse mesh or weave and the other of fine silk bolting cloth. The insects after they have been collected may be placed in cans, jars, and the like for transportation back to the laboratory.

The laboratory observation of aquatic insects is possible if they are not overcrowded in the aquaria and if the carnivorous species are segregated. Small balanced aquaria can be used but a battery jar is quite suitable. Only a shallow layer of sand and a few sprigs of *Elodea* are required for the set-up. The jar should be covered to prevent the escape of the adult form. Three to six specimens of each species will be enough for one given culture jar.

The food of the carnivorous species such as dragonfly and damselfly nymphs, caddicefly larvae, most of the water bugs and beetles, may consist of: other insect larvae, snails, small crustaceans, tadpoles, newts, small fish and even lean beef and liver. The herbivorous species such as mayfly nymphs, midge larvae and water boatmen feed on decaying vegetation, algae and water plants.

An insect aquarium. It is strongly recommended that at some time during the school year the biology laboratory establish an insect aquarium. It can be planted in the usual way with *Vallisneria* and *Elodea* being the most numerous plants but there can also be included several fresh-water algae. Visit local ponds and streams and collect quantities of vegetation from near the bottom and bring this back together with any of the captured larger adult insects or larval forms. Out of the mass of vegetation one can usually find great numbers of small insect larvae which can be segregated into a small dish. After all of the forms have been obtained, introduce them into the aquarium. There should be some of the large beetles, dragonfly larvae, mayfly larvae and the like. Some forms will naturally prey upon others, but even this is of interest to anyone who is trying to understand the complicated problems in aquatic biology. If it should be that any of the specimens seem to die for no particular reason, then some thought should be given to the oxygen content of the water. Indeed, it might be necessary to aerate it artificially. Generally speaking, the oxygen requirements will have been met if the tank has been heavily planted before the introduction of the insects. The aquarium should be provided with a loose-fitting glass cover and preferably a screen top extending up above this.

Equipment . . .

All of the field and laboratory equipment needed for the collection and care of living specimens may be secured from the General Biological Supply House at Chicago. Consult your latest Turtox Catalog for descriptions and prices of nets, dredges, seines, traps, cages, culture dishes, aquarium tanks, terraria, foods, diets, accessories and hundreds of other useful items.

TENTACULATA

MARINE BRYOZOA

Colonies of *Bugula turrita* and *B. flabellata* may be transferred to marine aquaria, where they will sometimes live for a week or so. The larvae may be cultured and colonies grown for long periods in running sea-water, but this is possible only in well-equipped sea-coast laboratories. (See discussion on pp. 178 and 179, "Culture Methods for Invertebrate Animals" by Benjamin H. Grave of DePauw University.)

FRESH-WATER BRYOZOA

Most students are more or less familiar with the marine Bryozoa, of which *Bugula* is the most generally used representative, and most laboratory courses in invertebrate zoology also include a rather brief examination of *Pectinatella,* or one of the other common fresh-water forms. However, in spite of the fact that the fresh-water representatives of this group are very generally distributed and often of common occurrence, the majority of them remain quite unknown to the average student. Many teachers of excellent training and long experience have told us that they have never seen a living bryozoan colony. It seems to us, therefore, that it will not be out of place to offer a few suggestions on finding and collecting some of the forms which are often so plentiful in our ponds and streams during the summer months.

The Bryozoa are commonly called moss-animalcules, due to their superficial resemblance to fuzzy, moss-like incrustations. An examination of a colony with a good hand lens, however, will reveal many separate animals (zooids), of rather complex structure and of a delicate lacelike beauty. In fact, if a colony is left undisturbed for a few minutes in a shallow dish of pond water and then examined, the effect is comparable to a bed of colorful living sea anemones. Delicate, flower-like heads appear and groups of translucent tentacles wave back and forth in the water.

All fresh-water bryozoans are sessile and most colonies are permanently fixed to their supports. In a few forms (*Cristatella* and *Pectinatella*), the colony itself has the power to move slightly. These two forms may occasionally reproduce by fission of the colony, the two portions moving apart after dividing. In general, however, reproduction of the fresh-water bryozoans is accomplished by means of (a) the union of sex cells or (b) the formation of statoblasts. The larvae of most of the fresh-water forms are not free-swimming, but develop in the uterus until they are young colonies. These young colonies are then set free and settle or float to some support, where they attach themselves. The statoblasts, each of which may also develop into a young colony, are commonly called winter bodies. They are produced during the late spring and early summer as well as in the autumn, however, and they undoubtedly serve as the principal means of distribution, as well as acting as a protective form in which the organism may survive the winter and periods of drought.

The bryozoans occur in both quiet and fast-flowing waters; and some forms are quite cosmopolitan in their distribution. *Plumatella,* for instance, has been recorded from every continent, except Africa. They are found in lakes, ponds, rivers, rapid streams, springs, reservoirs, and certain forms are not infrequently of economic importance due to their growing in large masses on the insides of water mains. In general, look for them at rather shallow depths and in dark locations. They do not thrive in bright sunlight and are most frequently found in places where shade or over-hanging banks make a subdued light. The sides and under surfaces of submerged logs and branches are likely locations, as are the undersides of waterlily leaves. The colonies occurring in still water are most likely to live in an aquarium.

Care upon Arrival. If you purchase cultures of Bryozoa, plan to use them as soon as possible. *Plumatella* and most other forms available during the winter months are a little difficult to ship and they can seldom be maintained for more than a few days after delivery.

Therefore, use them for study as quickly as possible. If some material is left over, place it in a balanced aquarium. Such a transplanted colony will usually disappear after a few days, but it may, nevertheless, establish itself in your aquarium and reappear as new colonies a month or so later. However, when new colonies do appear in an aquarium, they sometimes grow quite rapidly and may live for many months.

MOLLUSCA

LAND SNAILS. *(Helix* **and others)**

Many snails are terrestrial and at least a few kinds can be found in most parts of the United States. However, land snails are most plentiful in regions of moist woodlands and they attain their largest size and greatest abundance in the tropics. Because it is of large size, is easily obtained and is convenient for study, the large European edible snail, *Helix pomatia,* is much used in school laboratories.

Helix and other land snails may be kept in a moist and well-planted woodland terrarium. (See section on *Terraria* in appendix.) The terrarium should contain a layer of humus and leaf mold and some well-rotted wood, and should be planted with mosses, ferns, and other plants. If fed lettuce regularly, the snails will not destroy the natural vegetation.

Native land snails will breed in a terrarium if fed regularly. Many species thrive on a diet of ten parts of dry rolled oats to one part calcium carbonate, with an occasional feeding of celery tops, lettuce or other soft vegetation. In a large terrarium containing natural humus and decaying leaves, a few land snails will live for many months and require no special attention.

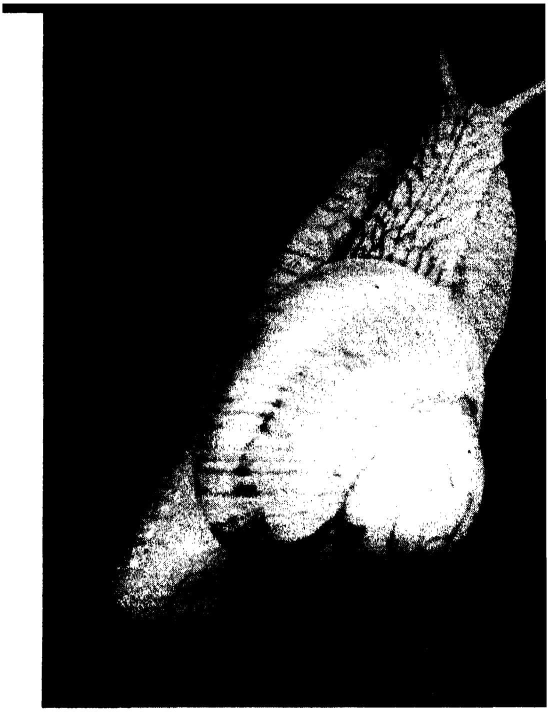
AQUATIC FRESH-WATER SNAILS

There are many kinds of fresh-water snails and at least a few species are common inhabitants of most permanent bodies of water. They may be collected in ponds, lakes, and streams, where they will be found attached to aquatic plants, stones and sticks, or in the sand and mud. Snails from quiet waters, rather than specimens from a rapidly flowing stream, live best in a balanced aquarium. They may be kept in a balanced aquarium of any size, where they will reproduce, allowing opportunities for the study of the various stages of development. They are hearty eaters and are valuable because they feed upon any algae that may be growing upon the aquarium plants or on the glass sides. Snails are also valuable as scavengers in an aquarium; they consume excess fish food and decaying vegetable matter, thus preventing the fouling of the water.

When snails are placed in an aquarium, they not only eat the algae; but, if food is scarce, some species will feed on the tender-leafed plants such as *Elodea* and *Nymphea.* However, this situation can be overcome by feeding lettuce once a week. They also may be fed shredded shrimp and other foods. Because snails eat so voraciously, they deposit large quantities of fecal material in an aquarium, which tends to encourage bacterial growth and the development of infusoria. An excess accumulation may be siphoned off at regular intervals, usually about twice a month. Occasionally, snails in an aquarium develop white spots on the shell which is an indication that the water is too acid and erosion of the shell is taking place. The addition of plaster of Paris or ground cuttle bone to the water will remedy this condition quickly. When raising snails in quantity, best results are obtained if the eggs and young are removed to special culture dishes or to small balanced aquaria containing no fish or other animals which might prey upon them.

The following snails are commonly studied in school laboratories, and all of them live well in balanced aquaria:

Helisoma trivolis, or brown ramshorn snail, is a very common species and a good aquarium



Right: Helix pomatia, the edible land snail in extended position. These large snails live nicely in a woodland terrarium.

inhabitant because it eats only algae, decayed vegetable matter, and excess fish food. The eggs are laid in clusters embedded in clear jelly.

Lymnaea palustris, a long cone-shaped snail, is usually found in abundance in Lemna-covered ponds. This species is not difficult to maintain in live tanks. The eggs are laid in irregularly-shaped masses of clear jelly.

Physa gyrina differs considerably from the other snails mentioned in that its shell is left-handed or sinistral; that is, when the shell is held with the apex up and the opening toward the observer, the opening is on the left. Snails which have the opening on the right side are considered right handed or dextral. The shell of *Physa* is thin and fragile and must be handled carefully. This species is very prolific and lives successfully even in stagnant water. The eggs are laid in long, narrow masses of clear jelly.

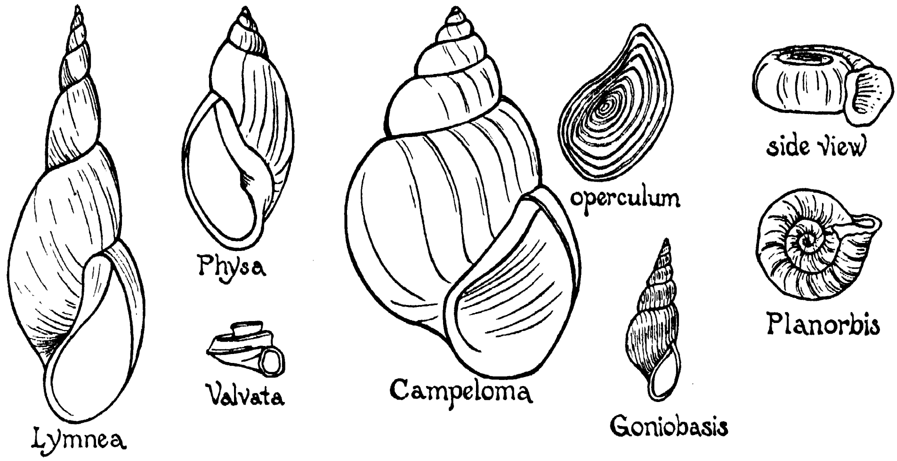
Goniobasis sp. The shell of this species is rough, rather heavy, and cone shaped. In the aquarium it confines its feeding to algae and decomposed plants.

Campeloma is a live-bearing species, the shell of which is very thick and solid. Even though it is a good aquarium scavenger, its diet should be supplemented with lettuce leaves.

Planorbis rubra. The red ramshorn snail, which is a variety of the brown *Planorbis*, is an importation from Denmark, often termed "The Copenhagen red snail." It is very attractive and similar in size and habits to the brown species. The eggs are laid in jelly-like masses which are pinkish in color. If the brown and red ramshorn are kept together, they will interbreed and the red strain will disappear.

Viviparus malleatus is a Japanese species commonly termed "the Japanese live-bearing snail" and resembles *Campeloma* in the shape of shell and the presence of an operculum; but the adult Japanese snail is much larger. It moves about slowly in the aquarium and does not eat the water plants but feeds on the algae. The sexes are separate and may be distinguished by the difference in the tentacles. In the male, the right tentacle is curved; whereas, in the female, it is straight.

Ampullaria paludosa is a native snail which compares in size with the Japanese snail. It is found in Florida and Georgia and belongs to a group, the majority of which are tropical. It has been commonly termed "Infusoria Snail" because, being an enormous eater of plant life, the



Common types of fresh-water snails.

large amount of fecal material indirectly aids the growth of infusoria. This snail will destroy the plants in an aquarium unless lettuce is fed in sufficient quantities. It is an egg-laying species. The eggs (size of a small pea) are pink in color.

Ceratodes sp. The striped Columbia snail is similar in feeding habits to the above and requires extra feedings of lettuce leaves. The shell is very showy and of the ramshorn type. Eggs are laid in large white clusters.

Lymnaca sp. The African paper-shell snail is a very delicate and fragile species. It requires more warmth than the other species of snails (water temperature around 75 degrees) and thrives best without the presence of other animal life. It should be given extra feedings of lettuce leaves. The eggs are laid in large masses of clear jelly.

Neritina reclivata. The Florida marble snail is a tropical species with a thick, attractively marked shell. It is a very good aquarium scavenger which does not eat the aquatic plants. Adult specimens live for many months in a balanced aquarium.

AQUATIC MARINE SNAILS

Some marine snails occur in great abundance and several species may be collected from almost any tide-pool. They are easy to transport and the smaller kinds will live for months or even for years in a small salt-water aquarium. *Nassa* and *Urosalpinx* are common on the Massachusetts Coast, and the Bleeding-tooth Snail (*Nerita*) is plentiful in Florida waters. These and many other kinds will live well in a marine aquarium of as little as 6-gallon capacity. They require no attention and feed upon the unicellular algae which grow in all established aquarium tanks.

(See section on *Marine Aquaria* in appendix.)

FRESH-WATER CLAMS. *(Anodonta sp.* and others)

Living clams or fresh-water mussels can be found in most localities with very little trouble and clams of some species occur on practically all sea-coasts. Look for the fresh-water clams in the shallower portions of lakes and rivers. They ordinarily burrow in the sand with only the posterior edge of the shell projecting into the water and, as they move slowly along, they leave a very distinct trail in the sand or gravel. Specimens will remain alive for several days if kept cool and wrapped in moist paper. Select very small clams (not more than two inches in length) for the balanced aquarium.

Clams obtain their oxygen from the water which is taken in through the inhalant siphon. The water passes through the gills and out the exhalant siphon. This method of respiration can be demonstrated by placing a small clam in a glass vessel of water containing some lampblack in suspension. If the mussel is left undisturbed for a few minutes, the two halves of the shell will separate slightly and the siphons protrude. Watch closely and the inward water current can be seen. The heart action can be demonstrated by opening a living clam. Do this by inserting a knife blade between the halves of the shell and severing the anterior and posterior adductor muscles. Turn back one half of the shell, at the same time noting the method of hinging of the two halves. The heart will be found on the mid-dorsal line directly under the hinge and its throbbing action can be seen plainly.

Small clams (1 to 2 inches in length) will usually live very satisfactorily in a well planted balanced aquarium, having a bottom layer of sand or fine gravel 2 or 3 inches deep. However, not more than two or three small clams should be placed in a 20-gallon tank. Large clams may be kept for months in a shallow tank through which running water flows continuously, providing the water has not been treated with chlorine or other purifying chemicals.

Note: When you purchase living clams, they may be shipped to you "damp pack," wrapped in moist material. Clams will live for several days in this condition. When you receive the shipment, unpack them immediately and place them in cold water.

Clam Glochidia

Clam glochidia are found in the gills of fresh-water clams during the late fall. They can be seen if the shell of the clam is opened. If glochidia are present, the gills will be greatly enlarged.

By removing some of the glochidia and placing them in a watch glass, they can be studied under the lower power of the microscope. The anatomy, as well as the movements of the larval clam, can be observed. They react to stimuli quickly. In nature, the young of many species attach themselves to fish until they are able to shift for themselves.

The following is an interesting experiment to be tried with living clam glochidia:

Place a considerable number of clam glochidia in a finger bowl of clean water and put into this two small fish. Observe where and how the glochidia attach themselves to the fish. If the glochidia settle to the bottom, agitate the water. Kill one of the fish and check the fins, gills, tail, and skin for glochidia. Place the other fish in a balanced aquarium and examine periodically and check condition of fish and glochidia.

MARINE CLAMS. *(Mya, Mytilus, Venus)*

Many of the marine bivalves such as *Mya arenaria, Mytilus edulis* and *Venus mercenaria,* and the common scallop, *Pecten irradians,* will live for several weeks (sometimes longer) in a marine aquarium. Small specimens should be selected for this purpose and, if possible, they should be placed in an aquarium of at least ten gallons capacity. The bottom of the aquarium should be covered with a layer of natural ocean sand 2 or 3 inches deep.

(*Note:* For more detailed directions, refer to the section on *Marine Aquaria* in appendix.)

All of the living specimens—terrestrial, fresh-water and marine—mentioned in this booklet are supplied by the General Biological Supply House. Hundreds of living animal—and plant—specimens are available at all seasons. For prices, refer to your copy of the Turtox Biology Catalog.

PISCES

FISHES.

Many of our native fishes—and many of the imported "tropicals"—will thrive in small aquaria. However, it is necessary to observe a few basic rules, the most important of which are: (1) Select small specimens and do not overcrowd your aquarium. See section on The Balanced Fresh-Water Aquarium in the appendix. (2) Select fish from ponds, lakes or slow-flowing streams; fish from rapidly flowing streams will seldom survive in a balanced aquarium. (3) Pugnacious species should be segregated in special tanks. (4) Feed sparingly and give aquarium fishes a considerable amount of living food. (5) Aerate your aquarium artificially unless it is well balanced with abundant plant growth. (6) Observe temperature requirements, especially in the case of tropical and marine fishes.

In the following sections are discussed: I Fresh-Water Fishes (cool water and warm water species, and egg layers and live bearers), and II Marine Fishes.

I FRESH-WATER FISHES *(A) Cool-Water Egg-layers*

In this group we shall consider a number of native fishes which may be collected locally, and others which are available commercially. We suggest that if at all possible one should collect some of the fishes in his own locality because in so doing, one may observe their natural habitat, a factor which is of invaluable assistance in keeping them in the laboratory.

Fishes for aquarium use may be found in all fresh water lakes, streams and permanent ponds. Mudminnows, bullheads, and sunfishes are widely distributed and easy to collect. The mudminnows and bullheads are found near the bottom of the ponds where they feed, whereas the sunfish remain close to the surface of the water. The sticklebacks, dace and darters prefer clear, flowing streams. Fishes should be brought from the field to the laboratory in large containers with plenty of water, especially if the weather is warm. At the laboratory, they should be transferred to the aquarium, but only after the temperature of the water in the collecting container has become the same as that in the aquarium. Sudden changing from collecting pond to aquarium, if the temperature differs greatly, may be fatal to the fishes.

It is important not to overcrowd a balanced aquarium with fishes. One inch of fish to every gallon of water in the aquarium is a good rule to follow. If the tank is a six gallon size, then six one-inch sunfish, or three two-inch sunfishes are satisfactory. It is interesting to note, however, that more fishes can be kept in an aquarium if the temperature of the water is low. Of course, where aeration of the aquarium is possible, the ratio of fishes to water capacity may be increased.

An aquarium containing fishes should always be covered with either a screen or glass top. There are times when active fishes leap clear of the water, go over the side of an uncovered aquarium and are found dead on the floor. If a glass plate is used, the water in the aquarium should be about one inch below the glass top; this small air space is beneficial for the escape of gasses from the tank. The top should not fit so snugly that circulation of air is impossible. During the summer months especially, a screen covering is preferable to glass because it permits better circulation. While a screen covering allows more evaporation, it is not harmful since the water added to make up for this loss acts as a stimulant to the fishes, as well as to plants and other animal life.

Feeding aquarium fishes is an important factor. The first rule to follow is never to overfeed them because left-over food fouls the water, promotes growth of algae and infusoria and, finally, may cause the death of the fishes. The fishes should be fed daily and in small amounts which can be eaten in five to eight minutes. It is not necessary to feed fishes unusually large quantities on Friday so that they will have food over the week-end. There is sufficient food in a balanced aquarium to keep fishes healthy even though not fed for a day or more. Different species require different foods. The best type of diet for most fishes is one which alternates living with prepared foods. It is difficult to obtain a supply of live food at all seasons of the year, especially in the winter, but a culture of Enchytrae can be kept in the laboratory for that purpose. Some fishes such as sunfishes, bullheads, dace and goldfish do well on dry foods; whereas others like sticklebacks require an abundance of live food or they will starve to death.

In dealing with cool water fishes, it is important to keep various species separate because of their habits. Sunfishes are bullies and, in a tank containing various sizes, the larger torment the smaller until they are killed or die of injuries. Sunfishes molest any fishes in the tank which happen to be smaller; but, if the other fishes are approximately of the same size as the sunfishes, they will get along very well together. A pair each of small sunfishes, mudminnows and bullheads get along well in a community tank. Bullheads thrive in any tank—remain near the bottom and are useful as scavengers. Red-bellied dace are attractive in an aquarium and with them can be kept a pair of darters. Dace are active; but the darters stay near the bottom and remain quite inactive until feeding time. Sticklebacks are quarrelsome fish and fight among themselves. If more than one pair are to be kept peacefully in an aquarium, the tank should be heavily planted to aid the smaller ones in hiding from their larger brethren.

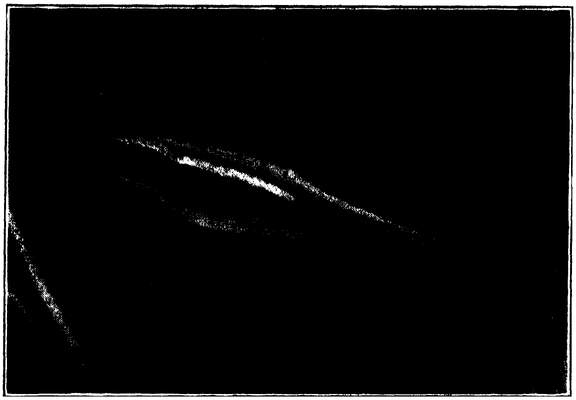
In breeding cool-water egg-laying fishes it is advisable to use a separate tank to breed each individual species. An assortment of different varieties of fishes makes it difficult to keep the non-interested fish from eating the eggs and fry as they appear. The breeding tank should be large to allow plenty of room for the adults. The larger the tank the easier it is to rear young especially when working with egg-layers where large numbers of fry are produced. The aquarium should be thickly planted with Vallisneria, Elodea, Cabomba, Myriophyllum and a few floating plants such as Riccia and Salvinia in order to give the adult fishes ample plant life on which to deposit their eggs. It is wise, after the eggs are laid, to remove the parents from the breeding tank since they relish the eggs and the baby fishes; but if this removal is not convenient, then dense plant growth aids the young in escaping from their cannibalistic parents.

The success in raising fish from eggs to adults depends upon the feeding of the newly hatched fry since in this stage the majority of fry starve if not properly fed. The first few days after hatching the young are sustained by the remaining food in the yolk sac. After this is absorbed the young are still so small that they are unable to accept the ordinary prepared or live foods, offered larger fishes. The majority of finely ground foods are too coarse and therefore unsatisfactory but when no other food is available, hard boiled egg yolk broken up in water to form a good infusion may be used in an emergency. The best food for newly hatched fry is "infusoria," consisting mainly of Paramecium and Euglena. Field collections of Infusoria can be made with a fine net and subcultures be prepared from this material for use as food. Direct feeding of field collected material often introduces parasites which attack and kill the fish. The safest method is to prepare a mixed protozoan culture in the laboratory by using the common hay infusion method. The Infusoria in the culture for feeding purposes should be abundant enough to give the water a cloudy appearance. The quantity of this culture for each feeding depends upon the number of fry, a pint given twice daily to two hundred fry is adequate food. If the fish are to develop rapidly, the Infusoria feedings should continue from two to three weeks depending upon the rapidity of growth of the young fish. If they show good growth, feedings of the nauplius stage of brine shrimp, sifted Daphnia and finely ground prepared foods can be started; and later the size and variety of food can be increased by adding chopped earthworms, mosquito larvae, Enchytrae and dried shrimp to their diet.

Goldfish *(Carassius sp.)*

Goldfishes have been popular for the small aquarium and out-door pools for many years because they have simple breeding habits and the ability to adapt themselves to a wide range

Left: The common killi-fish or Fundulus.



Right: Red-bellied Dace.

of water temperatures. Temperatures of from 50° to 75° (all temperatures are Fahrenheit) are not harmful and the food problem is easily solved since they eat a large variety of prepared as well as living foods. Bread crumbs, cereals, dried shrimp, snails, earthworms, Daphnia are eaten readily. When attempting to breed goldfishes, a tank of 10 to 15 gallons should be used. It should be planted heavily with Cabomba, Myriophyllum and water hyacinths so that the adhesive eggs can be attached easily. Goldfishes will breed when two years old and, where conditions are favorable, a number of times during the year. The sexes can be distinguished easily in the breeding season. The male has whitish spots on the gill plates; the female when ready to spawn has an enlarged abdomen. Spawning takes place in water temperatures of 60° to 70° and is usually preceeded by the male driving the female for several days. When ready to spawn, the female swims over the aquatic plants and deposits the eggs directly onto them. The adults should be removed after egg-laying has been completed. The eggs, which are the size of a pin head, hatch in 3 to 6 days and should be fed Infusoria until they are able to eat finely ground foods. An over-supply of fry need not be a cause for worry since the cannibalistic nature of the fish is evident early in the young and many are eaten.

Medaka *(Aplocheilus latipes)*

The medakas are small silvery-yellow fishes about one and a half inches long. They are easy to keep in small aquaria of 3 to 6 gallon size and can withstand temperatures of 50° to 75°. Feeding is no problem because they eat almost any food. When attempting to breed this species the water temperature should be kept around 68° to 75°. Sexes are distinguishable by the fins; in the male the pectorals are larger than in the female and are pointed, and the caudal fin of the male is square whereas in the female it is rounded. The eggs are expelled singly but adhere to the body of the female for some time and then are brushed off by the fish onto Myriophyllum and other fine-leafed plants in the aquarium. The eggs hatch in about a week to ten days. The fry should be fed Infusoria and then larger live and prepared foods.

Red-bellied Dace *(Chrosomus erythrogaster)*

The red-bellied dace is one of our common native fishes found in rivers and is a good species of fish for the community tank where temperatures range from 40° to 75°. These fishes are 2 to 3 inches long and in the breeding season are brilliantly colored with lateral bands of black, orange and red. The diet should consist of algae, Daphnia and dried foods. They are egg-layers but do not breed readily in the confined quarters of an aquarium.

Johnny Darter *(Boleosoma nigrum olmstedi)*

Rainbow Darter *(Poecilichthys caeruleus)*

Brooks and swift-flowing streams are the native habitats of the Johnny and rainbow darters. Specimens to be kept in an aquarium should be collected from slow-flowing streams because they become adapted to the quiet water of the aquarium more easily. These small, 1 to 2 inch, fishes spend most of their time on the bottom of the aquarium and move about in a jerky darting manner. The ability to turn their heads and wink makes them amusing members of a community tank. They can stand temperatures ranging from 40° to 70°, and prefer live foods such as Daphnia, Tubifex and Enchytrae, although they will accept some dry foods and can be trained to eat many others. Healthy specimens breed in the spring. The sexes can be distinguished in the breeding season by their color—the female is duller than the male, the head of the male becomes black and the first dorsal spine becomes smaller and club-shaped at the tip. Eggs are deposited among the pebbles on the aquarium bottom. The fry require the usual care.

Fresh-water Flounder *(Achirus and Trinectes)*

The flat-fish, *Achirus*, is found in both fresh and salt water and is similar to the marine sole in appearance. The general color is dusky olive mottled with vertical stripes. The fishes, which are 2 to 4 inches long, eat chopped meat, fish, bread, insects, earthworms and small crustacea. Temperatures from 40° to 80° are tolerated. They are not active, remaining curled in shallow sand or clinging to the glass side of the aquarium. They are egg-layers and in their natural habitat breed in the spring. They are difficult to breed in captivity.

Sticklebacks *(Eucalia inconstans)*

The sticklebacks, measuring 1½ to 2 inches, are one of the most courageous of all our native fishes and are found living in clear streams. Because of their quarrelsome nature these fishes require a large, thickly-planted aquarium. The water temperature may range from 35° to 75°. Live foods such as Daphnia and Enchytrae are necessary for the fishes although they will eat a few dry foods. The nest building habit of the male has made them unusually popular. The male, which is more aggressive and more brilliantly colored than the female in the breeding season, builds the nest of pieces of plants and debris near the bottom among the stems of the aquatic plants and then induces several females to lay their eggs in it. The eggs which hatch in 8 to 14 days are guarded and fanned by the male. He continues to guard the fry until they are able to shift for themselves. When the fry reach this stage the adults should be removed to prevent cannibalism. The fry should be fed Infusoria until they can eat larger living and prepared foods.

Common Sunfish *(Eupomotis sp.)*

The voracious and quarrelsome sunfish is commonly found in all fresh-water ponds and streams. It is a very hardy fish, withstanding temperatures from 35° to 75°. Earthworms, snails, Daphnia, mosquito larvae, small fish, floating plants, chopped beef and dry foods are readily accepted and this makes the feeding problem a simple one. Breeding can be accomplished in a large aquarium in the spring. The male can be distinguished from female by the conspicuous ear flap, luminous borders on the fins and the bright blue color of his dorsal and caudal fin.

The eggs are laid in a depression in the sand prepared for that purpose by the male and the adhesive eggs become attached to stones and sand in the nest. The eggs are fanned and guarded by the parents until they hatch in 3 to 6 days at temperatures around 60° to 70°. The fry should be fed Infusoria until they are able to eat larger dried and living foods.

Black-banded Sunfish *(Mesogonistius chaetodon)*

The black-banded sunfishes are found in the cedar swamps of the eastern coastal states. The silver body is striped with six or more black bands. These fishes may be kept in a community tank but the water should be slightly acid and of a temperature of from 50° to 70°. Living food is essential to good growth but they will take dried shrimp and other food. Breeding and care of the fry are similar to the procedures given for the common sunfish. The temperature of water in the breeding tank should be kept around 66° to 72°.

Bullhead *(Ameiurus)*

The common yellowish brown or black bullheads are good fishes for the aquarium because they can live peacefully with other species and are useful as scavengers. Specimens 2 to 3 inches long are best for the aquarium of average size. Water temperature ranging from 40° to 75° is satisfactory and any available foods, living or prepared, are acceptable. Breeding requires large aquaria and fishes measuring 5 to 8 inches in length. The eggs are deposited in large, flat dug-outs in sand or mud which the male guards and fans. The fry are also guarded by the parents for some time.

Killi-fish *(Fundulus)*

The common killi-fishes are found in fresh, brackish and salt water along the Atlantic coast and are interesting specimens in the laboratory aquarium because they live either in fresh or salt water and can be transferred from one to the other without harm. When kept in a fresh-water aquarium, it is advisable to add one tablespoon of sea salt per two gallons of water. These hardy fish grow to a length of 4 to 5 inches and eat living and dried foods such as Enchytrae, Daphnia, brine shrimp, insect larvae, algae and shredded shrimp. Temperatures from 40° to 75° are satisfactory except for breeding when 68° to 74° is better. The female is brown with dark cross bars and the male is ordinarily dark green but in the breeding season is more vividly colored. Spawning takes place in late spring and the eggs (size of a pin head) are deposited on submerged or floating plants. The eggs hatch in 10 to 14 days and the fry are easily reared.

(B) Warm-water Live-bearers

The fishes to which the terms "warm-water" or "tropical" are applied are found in the warm waters of the world. Species are native to the Americas, southern Europe, Asia and Africa. Information on care and breeding of warm-water fishes has been compiled through the years in Europe as well as America. There are many variations in living and breeding habits of warm-water fishes which make them valuable as demonstration material in the biological studies.

The term "warm-water" need not cause anyone to shy away from these fishes, thinking that they require an untold amount of special equipment in order to care for them. If the room temperature in which the aquarium is located does not vary much above or below 68°, then a few pairs of guppies will live in a six-gallon aquarium without any further attention to the heating requirements of the water. All species of warm water fishes do not thrive so well at low temperature as the guppies, but an average temperature of 72° to 78° is safe for almost any species. Many fish fanciers make the serious mistake of keeping the temperature too high. Of course, some species require higher temperatures but these are special cases. Also, a slightly higher temperature is necessary when young are hatched or born. In the laboratory where temperature varies greatly at night and especially over the week-ends, it is advisable to use a thermometer, heater and thermostat for the aquarium. The thermostat may be adjusted to the desired temperature, after which it will remain constant as long as the heater and thermostat are in operation.

Right: Swordtails give birth to living young and live very well in a small aquarium.

A tank for keeping and breeding the warm water live-bearing fishes should be large and planted with *Elodea, Sagittaria, Vallisneria* and some floating species, such as *Riccia* or *Salvinia* to afford cover for the young. The tank should receive some direct sunlight daily because it not only is excellent for the fishes, but also encourages the growth of algae which most live-bearers enjoy as part of their diet.

The warm water live-bearing species considered in this discussion are: *Lebistes reticulatus,* the guppy from South America; *Platypoecilus maculatus* and *Xiphophorus helleri,* the Platys and Sword-tail from Mexico and Central America; and *Mollienisia latipinna* and *Gambusia,* the Molly and Mosquito fish from southern U. S.

In general, the care and breeding habits of the live-bearing fishes are similar. The best temperature for all-around purposes should range from 68° to 78°. These fishes are prolific breeders, usually having young every four weeks, with the exception of the mollies and mosquito fish which bear young at 5 to 10 week intervals. An interesting phenomenon to observe is that a mated female is capable of giving birth to several hatches of young without further mating. Sexes are easily distinguished in the adult live-bearers; in the majority of species the female is larger than the male fish and the anal fin of the female is fan-shaped while that of the male is pointed. In the males of the sword-tail species the lower rays of the caudal fin are prolonged and form a sword-like extension.

Live-bearers are predominantly omnivorous and their diet should consist of both plant and animal foods; such as *Daphnia,* chopped earthworms, shredded shrimp, algae, crushed spinach and lettuce leaves, *Enchytrae* and mosquito larvae. The mollies which are mainly herbivorous in their feeding habits should be fed more plant than animal food.

Almost any of the live-bearing species may be placed in a large community tank. *Gambusia* is the most pugnacious of the group and often kills the snails in the tank and annoys the other fish by nipping their fins. Plenty of live food is a good method of keeping them peaceful.

When attempting to breed these fishes it is best to place individual species in separate aquaria. This should be done before the condition of the female has developed too far because moving gravid females may bring about premature birth and cause the death of both young and mother fish. When moving fishes from one tank to another at breeding time be sure water temperature is identical in both tanks.

Adult guppies, sword-tails and mosquito fish have a tendency to eat their young. If the parents are given large quantities of live *Daphnia* and *Enchytrae,* some of the cannibalism may be checked, especially if the tank is thickly planted to afford hiding places for the young. However, when a large proportion of the brood are to be reared to maturity the young should be removed from breeding tank. The young which are of good size when born are easily reared if fed on finely powdered fish food, nauplius of brine shrimp and sifted *Daphnia.* Overcrowding of young in a small tank slows up the growth of the entire group. Young fish need plenty of room to develop rapidly; a dozen to fifteen young will thrive in a six gallon aquarium.

(C) Warm-water Egg-layers

The egg-laying species of fishes here discussed include *Barbus,* the barbs from India; *Betta* *splendens*, the fighting fish from Siam; *Brachydanio*, the danios from India; *Pterophyllum eimekei*, the angel fish from South America; and *Ambassis lala*, the glassfish from India.

The requirements for maintaining egg-laying species are similar to the methods used with the live-bearers. Large aquaria of 10 to 15 gallon capacity are best for them and a dense growth of plants is beneficial. Experienced breeders of egg-laying fishes have learned that an aquarium which has been balanced and aged for a short time is preferable to a newly balanced one in which to keep and breed a pair of egg-layers. Temperature for egg-laying species should be maintained at a slightly higher average than for live-bearers, a good all around temperature being 72° to 80°. The temperature of the breeding tank should be kept around 78° to 82°. Sexes are difficult to distinguish in this group except at breeding time. The females are usually larger than the males, but the males are more brilliantly colored. This group of fish is also omnivorous in feeding habits but prefer live foods to prepared foods. Living *Daphnia*, *Enchytrae*, mosquito larvae, earthworms, some algae, shredded shrimp and other prepared foods are enjoyed by them.

The egg-laying fishes show some interesting variations in breeding habits and each species presents its own particular problem. The strikingly colored and active *Brachydanio* is the best species to use in a first attempt at breeding egg-laying fishes. This species is more hardy than the others and adapts itself to the confining area of a small aquarium. Since the adults have a decided tendency to eat their own eggs the breeding tank must be prepared with that in mind. The water in the aquarium should be shallow, about six inches deep, and the bottom of the tank should be covered with several layers of large pebbles or marbles. This set-up allows the eggs to settle to the bottom and lodge among the stones, before they can be eaten. When spawning is completed the adults should be removed. The eggs hatch in 48 hours and after the fry have absorbed the remaining egg yolk they are given feedings of Infusoria until they can take larger live and prepared foods. (For further information on care of fry refer to Turtox bulletin on Cold-Water Fishes.)

The Barbs in their breeding habits are somewhat similar to the Brachydanios. The bottom of the breeding tank should be covered with a good growth of *Nitella* or some other fine-leafed plant to form a mat and thus protect the eggs from the hungry parents. When spawning takes place the eggs are dropped wherever the female fish happens to be swimming, and fall to the bottom or adhere to the plants. The adults should be removed after spawning. The egg hatches in 36 hours and the young should be fed Infusoria and gradually food of larger size.

The Siamese fighting fish, *Betta splendens*, is a bubble-nest builder and can live in water of low oxygen content. The males are pugnacious and fight among themselves and only one should be included in a breeding tank with the female. The breeding tank should have a good portion of floating plants such as *Salvinia* or *Riccia* and the tank should be kept covered to prevent fish from jumping out and also to prevent air currents from destroying the bubble-nest. Before spawning the male constructs a nest of air bubbles on the surface of the water. After the eggs are laid and fertilized, the male gathers the eggs, surrounds them with air bubbles and floats them into the bubble nest. After spawning the female should be removed. The male guards the eggs; if any fall to the bottom he returns them to the bubble-nest and cares for the young for one to three weeks, when it is time to remove him also before he begins to eat the young. The fry require the same attention as suggested for other baby fishes.

The glassfish, *Ambassis lala*, and angelfish, *Pterophyllum eimekei*, have somewhat similar breeding habits. Both species attach their eggs to aquatic plants. The glassfish deposits its eggs on the fine-leafed plants such as *Myriophyllum* and *Riccia* near the surface of the water, and the female angel-fish deposits her eggs on the broad leaves of *Cryptocoryne*, Spatterdock and *Sagittaria*. The adult angel-fishes guard and fan the eggs for some time. The eggs of both species hatch in 48 hours and the fry should be started on Infusoria and gradually larger foods.

II Marine Fishes

As is the case with fresh-water fishes, *small* specimens of marine fishes should be selected for aquarium study. The aquarium in which they are kept must be well aerated and the water temperature must be maintained at a proper level. Most of the living salt-water fishes sold by supply houses are tropical forms from the Florida Coasts and of outstanding interest are the brilliantly colored coral-reef fishes.

Care upon arrival. Take the temperature of the water in the shipping container and compare it with the temperature of the water in your marine aquaria. If the former is colder, let it warm up *gradually* in a warm room before removing any of the specimens. The temperature variations should not exceed five degrees when the specimens are transferred. *Sudden* temperature changes are nearly always fatal. Transfer living fishes to your aquarium with a small dip net, doing it as gently as possible.

Care in the Laboratory. In the case of tropical marine fishes two factors are of great importance. *First,* temperature of the water must be maintained at the proper level. Coral reef fishes require a temperature range of 70° to 80° F. at all times, and many forms will die if the temperature drops below 60° F. *Second,* the aquarium must be well aerated, by means of an air pump or other means. This is necessary because most marine aquaria do not contain sufficient living plants to "balance" the plant and animal forms as is the case in a balanced fresh-water aquarium. The tank should be equipped with a loose-fitting glass cover, to retard evaporation and to prevent fish from jumping out.

Feeding. Many of the tropical marine fish will accept prepared fish foods. All relish natural foods, however, and should be given occasional meals of living brine shrimp larvae, other crustaceans, or small living worms. At least once a week they should be given finely chopped oysters, clam, fish or raw meat. Canned shrimps, chopped into very small pieces are a very good food.

Sea-horse and Pipe-fish

The Dwarf Sea-horse (*Hippocampus zosterae*) and the Pipe-fish (*Syngnathus floridae*) are both exceptionally interesting fishes for observation in a salt-water aquarium. They live very well in a small (5 to 10 gallon) tank, and both species have thrived for long periods and produced young in aquarium tanks in our Chicago laboratories. The males of the sea-horse and pipe-fish are equipped with brood pouches in which the eggs are carried until the young hatch.

Care upon Arrival. Living sea-horses and pipe-fishes are shipped via express from one of our Florida collecting stations and are usually available for delivery from November 1 to March 15. When received, the sea-water in the shipping container may be very cold; if this is the case, allow it to warm up *gradually* to room temperature before removing the fish. *Never* transfer living fishes from cold to warm water (or vice versa), as *sudden* temperature changes are usually fatal. When the water in the shipping container is approximately the same temperature as the water in your aquarium tanks, the fishes may be transferred to the tank. Do this as gently as possible, using a fine-meshed aquarium dip-net.

Care in the Laboratory. The sea-horse and the pipe-fish are hardier than most marine fishes and will live satisfactorily in a salt-water tank of as little as five gallons capacity. The water should be well aerated and kept fairly warm. These fishes will tolerate a temperature range of 40° to 80° F. but will live best in water ranging from 70° to 75° F. The aquarium should contain some supporting materials (marine algae, pieces of branch coral, irregular rocks, etc.) to which the sea-horses may attach themselves when not swimming.

These fishes require living food and will readily accept the brine shrimp (*Artemia salina*) which is easy to rear, and other small crustaceans. The young also eat marine diatoms and other microscopic forms which usually grow in abundance in all salt-water aquaria.

Left: Feeding Red-spotted Newts in a finger bowl dish.

AMPHIBIA

SALAMANDERS

There are many kinds of salamanders which may be kept in the laboratory. A few of the larger kinds need running water tanks, many small aquatic salamanders will live in balanced aquaria, and a large woodland terrarium is a suitable habitat for most of the terrestrial forms.

Newts. The common red-bellied newt receives our first attention, because, without a doubt it is the one most generally seen in the laboratory. There are two distinct phases in the life of this animal; the red eft or land phase and the olive green—red striped, red spotted aquatic phase. The red eft is an ideal woodland terrarium animal; its brilliant color contrasting so vividly with that of the moss-covered terrarium floor. This phase does *not* require the aquatic habitat and *should never be placed in an aquarium.* It feeds upon very small insects, young spiders, small ants and the like. White worms (*Enchytraeus*) are relished. Bits of lean beef and calf liver can be fed with forceps. The animals being so very small require but infinitessimal amounts of food.

The aquatic phase of the newt should be kept in an aquarium. It is well if the tank is heavily planted so that the leaves form mats in some places on the surface as the newts like to crawl out upon them at will. Feed this animal by removing it from the tank to a fingerbowl of tepid water into which has been dispersed small particles of lean beef, liver or the like. Leave it here until it has eaten as much as it likes, then wash it off and return it to the aquarium. About once a week is satisfactory for feeding unless the animal has a voracious appetite, in which case you may feed as often as it appears to be hungry. Once the animal has become accustomed to a regular feeding schedule and to this type of food one may be successful in feeding it in the aquarium. The only danger is that food particles introduced might not be eaten and then decay, thus fouling the aquarium. This point cannot be over-emphasized in feeding any aquarium inhabitants—excess food is very apt to spoil the entire set-up.

(Most salamanders will eat ant eggs and chopped up pieces of earthworms.)

Axolotls. The larvae of various salamanders can be kept in the balanced aquarium. They are voracious feeders, frequently taking as food animals as large as themselves. In fact, they are cannabalistic and the stronger ones may devour the weaker if several are kept together. Calf liver cut up into small chunks, forms a very satisfactory food. Axolotls should be watched daily at about the time metamorphosis is expected to take place for as soon as the adult stage is reached they should be transferred to terraria—away from the completely aquatic environment.

Adults of the tiger salamander (*Ambystoma tigrinum*), the spotted salamander (*A. maculatum*), the marbled salamander (*A. opacum*), and several others make good terrarium inhabitants, thriving in either the woodland or the semi-aquatic habitats. They frequently burrow beneath the moss covering to hide but are less likely to do so if some crevices between rocks or small "logs" are provided. They feed upon mealworms and other small insects but one can train them to accept, quite willingly, large amounts of hamburger. They have to be fed with forceps at first but eventually will feed out of a small dish. Feed at regular times and less trouble will be encountered. Vary the diet with liver and experiment with various other raw meats.

Triturus pyrrhogaster. This form (the red-bellied salamander) lives well in the ordinary balanced aquarium and may be cared for in the same manner as described above for the aquatic phase of the red-spotted newt. This type of environment is also suitable to the giant newt of the pacific coast, *Triturus torosus.*

Plethodons. These small salamanders make good terrarium animals, preferring the moist but not wet woodland environment. They are delicate and therefore must be given careful attention. Their care approximates that indicated above for the red eft.

Necturus, Cryptobranchus, and *Amphiuma.* Young, small specimens of these salamanders may be kept in balanced aquaria, but the larger (average-sized) specimens are most successfully maintained in large running-water tanks. Where considerable numbers of *Necturus* are to be kept for long periods, they may be placed in wooden tanks in which the water flows slowly and a depth of about four inches is maintained. These larger salamanders will eat earthworms, minnows, small crayfish, water bugs and beef liver.

TOADS. *(Bufo sp.)*

Common toads do well in a woodland terrarium, as they do not require an aquatic habitat except during the breeding season. Small specimens should be selected, for the small toads adapt themselves best to the confines of a terrarium and their burrowing habits are less objectionable. A toad will burrow into the soil and the larger ones are likely to uproot many of the terrarium plants.

Terraria are planted in the usual way with 3 or 4 inches of humus and soil in the bottom covered over with mosses, lichens and other plants. Ferns of the dwarf varieties can be planted in one end. A group of rocks may be arranged in the opposite end and if there are some cracks, in which the toad may hide, perhaps he will take to them rather than resort to burrowing. Do not disturb the animal for quite some time after establishing it in its new home. Provide a shallow drinking dish.

Feed the toad living specimens at first—cockroaches, caterpillars, mealworms, flies if available, ants, young spiders and the like. Later, you may succeed in having the toad take several angle worms or even lean beef held in front of it at the end of a toothpick or broom straw. There is no danger of over-feeding, although it is not necessary to feed every day. Two or three times per week are generally sufficient.

Toads require warmth if they are to be active. When room temperatures fall below 70° F., toads usually burrow under and may not be seen for long periods. An electric light bulb suspended above the terrarium frequently has a beneficial effect upon them. They may not come out into the light, but it warms them up so that as soon as the light is removed they will usually hop out of their retreat and feed.

TREE FROGS. *(Hyla gratiosa* **and others)**

Tree frogs, or tree "toads" as they are commonly called, are plentiful in many sections of the United States, but because of their secretive habits and protective coloration, they are seldom seen by the casual observer. Tree frogs live in moist locations, spending much of their time in trees and bushes and, in the case of most species, resorting to ponds only during the breeding season. They live remarkably well in a school terrarium and are interesting amphibians for laboratory observation.

Care and Feeding. Tree frogs must be maintained in a humid situation where sufficient moisture is available at all times and the woodland type of terrarium is well suited to them. Screened terraria are not satisfactory; the best type is a terrarium housed in a standard rectangular aquarium tank with a glass cover or equipped with a cover partly of glass and partly of screening. In a terrarium of this kind the humidity is easily controlled and the tree frogs are protected from drafts and sudden temperature changes. The terrarium should contain loam and leaf mold and may be planted with mosses, ferns, liverworts and other woodland plants.

Tree frogs require living food and will readily accept almost any kind of small insects. They will occasionally take worms and will sometimes accept tiny pieces of raw meat presented on the end of a toothpick. During the winter months living *Drosophila* (Fruit flies) and cockroaches (both of which are easily reared in laboratory cultures) provide a very satisfactory source of food. Small mealworms may also be used.

BULLFROGS. (and other aquatic frogs).

Bullfrogs may be collected in swamps and lakes and they occur more or less throughout all the eastern half of the United States. However, most bullfrogs sold by dealers and supply houses come from the Gulf States, as these southern frogs are larger and are much more plentiful in the South. It is not uncommon for them to be rather sluggish when they arrive at northern destinations during the winter and spring months. They will become lively as soon as they are placed in water and allowed to warm up *gradually*, say, to about 75° F.

Upon arrival, the bullfrogs should be washed in clear water to free their bodies of any wastes which might have accumulated during shipment. Place them then in a large aquarium, probably one equipped with running water would be best. It should be screened over to prevent the frog from leaping out and dying when no one is in the laboratory. These animals can float on the water for long periods of time but should be provided with rocks or other supports upon which they can rest. If large quantities of bullfrogs are to be kept, the wooden tanks recommended in the section dealing with grassfrogs are very desirable.

Feed bullfrogs upon small crayfish, minnows, earthworms, young grassfrogs and the like. Green frogs may be fed earthworms, mealworms and flies. It is possible to train either of these frogs to take food to which it is unaccustomed in nature—lean beef, beef liver and even canned shrimp if it is dangled before the animal so that it appears to have motion.

Green frogs (*Rana clamitans* and other aquatic species) require about the same care as bullfrogs. Being much smaller, however, a few individuals will live nicely in a swamp or semi-aquatic terrarium.

The ideal way to care for these larger aquatic frogs would be in out-door pools. They would have to be constructed so that the frogs could not be subjected to undue annoyance from unwanted visitors. An electric light suspended but a few feet over the pool would attract ample insect food during the summer months. In northern locations, the southern bullfrog would have to winter-over in laboratory tanks as it cannot withstand the severity of our climate.

Turtox receives many inquiries each year from individuals who wish to start frog farms In practically all cases, such would be a foolhardy venture, certainly if one attempts to rear the southern bullfrog in northern ponds. Even if it were possible to do so, there would arise problems of disease due to overcrowding and of providing cheap and satisfactory food. All the while, the natural supply of frogs is growing with no cost except that of collection and it would be hard to conceive of a commercial venture being able to compete. So, unless one wishes to *experiment*, the answer to frog farming inquiries is—"before you invest—investigate."

Right: Adult Grassfrog, the most widely used laboratory animal.

GRASSFROGS. *(Rana pipiens* **and others)**

One of the most frequent inquiries reaching the Turtox Service Department is the one which asks, "How may I keep living grassfrogs in my laboratory?" The answer is not so simple as one might suspect, for different methods are used, depending on the *number* of frogs to be kept, the *length* of time they are to be maintained, and the time of year the stock is purchased or collected.

The small laboratory may wish to keep only four to six specimens for a relatively long time. A large woodland terrarium would be almost ideal, if there is a sunken dish in it in which water is kept. Or, the semi-aquatic terrarium can be used with success. In either case, you see that you will have provided the approximate environment afforded in nature. These are meadow frogs, frequenting almost dry fields in the summer in quest of insect food, and returning to the ponds for hibernation and subsequent egg-laying in the following spring. Feed living insects such as mealworms, cockroaches, small grasshoppers if available, flies, caterpillars, and the like. They can sometimes be trained to accept beef liver, lean beef, etc. moved before them at the end of a string or broom straw. See that each individual receives some food.

Some of the laboratories of our large universities wish to keep great numbers of frogs available for several weeks. Their care is often a real problem. We recommend large wooden tanks (cypress is perhaps most economical in the long run) with a gradual slope of pebbles, about ⅜" diameter, in one end. The tank is to be equipped with an inlet so that water is constantly trickling through it, and outlet which drains all but about ½" of water in the bottom. Not much water is needed, especially when the frogs are obtained during the summer. That which flows through the tank tends to keep it clean and free from wastes. However, flush it out thoroughly every four or five days. It is best to locate such a tank in the basement, where it will remain cool at all times. Keep it dark and do not disturb the frogs often. Inspect at least every third day (oftener if there has been a disease) and remove any frogs that have died or are in a weakened condition. If disease should become rampant, sort over all specimens and segregate those not in the best condition. Flush out the tank thoroughly, remove specimens to a temporary storage receptacle and sterilize the tank with a strong salt solution, a formalin solution or lime. Return the frogs only after a thorough washing out of the disinfectant. Always disinfect tanks thoroughly after each lot of frogs is used up and also just before another batch is to be introduced.

In such concentrations, it is seldom advisable to feed the frogs, as it would be an unending task. If kept cool, undisturbed, and dark, there will be but little activity and, hence, but little necessity for food. During the winter months, the frogs can stand much more water and the tank described above may be altered so as to keep a constant level of water about one to two inches deep.

Another method for maintaining living frogs consists of a tank (or any other suitable container) provided with a layer of damp (not wet) sphagnum moss. (The dry baled moss used by florists is suitable.) The slight amount of iodine in the moss appears to prevent red-leg and other infections. The sphagnum moss tank should contain only the damp moss—no water.

Care of Frogs upon Arrival. Just as soon as you have received your frogs, whether there be three or three hundred, open the package carefully and then inspect each one to be sure it has not suffered from its long journey. It is well to have a pail of fresh water handy and to wash the animals off before placing them in your tanks. Any frog which appears to be diseased should be segregated.

LIVING FROG EGGS AND TADPOLES

These notes apply particularly to eggs of the grassfrog (*Rana pipiens*) but are also applicable to the eggs of bullfrogs, tree frogs, etc. and to the common toad (*Bufo*).

Eggs. The eggs of the grassfrog (*Rana pipiens*) are laid in ponds and ditches between the last of March and the middle of April in the latitude of Chicago. Eggs of the spring peeper (*Hyla crucifer*) appear at about the same time, but toad (*Bufo*) eggs are not laid until the first part of May and bullfrog eggs are usually not found until June. When eggs are collected, they should be brought to the laboratory in pails of the pond water in which they were found.

For many years teachers who wished to demonstrate the development of the frog had no choice but to use the living eggs at the only time and during the very short period when they were available in the field. Now, however, laboratory-induced eggs of the frog and of other amphibians are available at all seasons, and Turtox supplies these living eggs (in early developmental stages) throughout the year. One of our free informational bulletins describes the method of producing laboratory-induced eggs and teachers can easily carry it out in the school laboratory.

Clumps or large masses of the freshly laid eggs may be placed in balanced aquaria or in dishpans of aerated water. Or, if uniform development is wanted, small lots of from ten to twenty-five eggs may be placed in finger bowls.

The rate of development of the frog egg is determined almost entirely by the temperature of the water. A temperature range of 50° to 60° F. is "normal" (that is, it approximates average field conditions), while a water temperature of 70° to 75° F. will cause more rapid development. At this latter temperature the young tadpoles will attain swimming size in about two days. A water-temperature higher than 75° F. is not recommended as it will kill many of the eggs.

Tadpoles. The young tadpoles must have food, and if they are to be studied for several weeks or longer they should be placed in fairly large balanced aquaria. The tanks should be well planted, containing aquatic plants, plentiful algal growth and bottom debris (dead leaves, algae, mud, etc.) from a pond or stream. The tadpoles will eat some artificial fish food and they may also be fed finely chopped beef; but it is essential that they have access to dead and living algae and an abundance of bottom debris. (Needless to say, they should not be kept in a tank containing fishes or aquatic insect larvae which may prey upon them.)

Large grassfrog and bullfrog tadpoles will eat finely chopped lean meat, cornmeal, cooked oatmeal and cooked spinach.

Metamorphosis in the grassfrog, spring peeper and common toad occurs during the first summer. The green frog (*Rana clamitans*) tadpoles metamorphose the second summer, and the bullfrog remains in the tadpole stage for from two to four years.

(*Note.* Metamorphosis of tadpoles will be accelerated greatly if they are fed a small amount of powdered thyroid. In some cases tadpoles fed on thyroid metamorphose into tiny adult frogs in less than ten days. See free Turtox bulletin, "The Effect of Thyroid on Tadpoles.")

Where Can I Secure Living Specimens?

All of the living specimens discussed in this booklet may be purchased from the General Biological Supply House, Chicago, Illinois. Some are available only at certain seasons, but the great majority can be supplied throughout the year.

Our living shipments are *guaranteed* to arrive at any school address in the United States—alive and in perfect condition.

REPTILIA

ALLIGATOR AND CROCODILE

The alligator is still fairly plentiful in some parts of our southern states and is also reared on "alligator farms" in Florida, Louisiana, and California. The American Crocodile is quite rare, being found wild only in the extreme southern part of Florida and on a few of the Florida Keys.

Care upon Arrival. Both the alligator and crocodile are sensitive to cold and the latter cannot be shipped when low temperatures prevail. If the specimens appear to be cold and sluggish upon arrival, allow them to warm up *gradually* and, when they become fairly active, place them in a tank or pan containing shallow water about 75° in temperature. If the specimens appear to be quite dead, do not discard them too quickly. Reptiles become cold and motionless when subjected to low temperatures, but will sometimes revive if allowed to recover gradually in a warm room.

Care in the Laboratory. Both alligators and crocodiles like warmth and they will live and grow best in a situation where the temperature ranges from 75° to 90° F. Provide them with a tank containing sand and some flat stones above water level at one end, with water three to six inches deep at the other end of the tank. This tank should be located where it will receive at least an hour or two of direct sunshine each day. It is important that the alligator tank be kept warm, for low temperatures over the weekends and during holiday periods when the school is closed may prove fatal. If natural sunlight cannot be provided, suspend an electric light bulb over the reptile tank and turn this on for three or four hours each day. Such an arrangement furnishes both heat and light, and works out well with most reptiles.

Feeding. Alligators and crocodiles are carnivorous and will accept almost any kind of raw meat or raw fish. They may also be fed small frogs, earthworms, and crayfish. The food should be placed *in the water* and left there for several hours. What has not been eaten should then be removed.

Food once or twice a week is usually sufficient. Reptiles eat little during the winter months, so do not be concerned if your pets refuse food for a period of several weeks. However, if they are kept warm and receive abundant sunshine, young alligators will usually eat freely within a week after arrival.

LIZARDS

Because of their activity, attractive coloration and interesting habits, lizards are splendid animals to study in school terraria. There are a number of native American species, all of which adapt themselves readily to captivity.

The Woodland Lizards

Anolis. No lizard is better known than *Anolis carolinensis,* the common American "chameleon." But the average person has no idea of its proper care and probably thousands of chameleons die every year for the want of the simplest attention. *Do not* try to keep *Anolis* in cigar boxes or screened cages; it cannot survive cold drafts and it *must* have sufficient warmth and moisture. An ideal cage for one or a dozen chameleons is a fairly large woodland terrarium, nicely planted with growing ferns and other fairly tall plants sturdy enough for the lizards to climb upon. A well-branched dead stick "planted" in one end of the terrarium is also desirable.

Left: Anolis, the American "Chameleon." These active and colorful lizards live well in a woodland terrarium if provided with warmth, moisture and living insect food.

The terrarium should be kept warm (70° to 80° F.) and it should receive plenty of sunlight. Its sides should be of glass (see *The Terrarium* in appendix) and a glass top is also preferable to one of screening. Sprinkle the plants with water once a day, for *Anolis* seldom drinks from a dish, but will drink the drops of water which remain on the leaves. For food, living insects are necessary. At first try to supply your chameleons with fruit flies, house flies and other small *flying* insects; later on they will probably accept roaches, mealworms, grasshopper nymphs and even very small earthworms.

Blue-tailed Skink. The five-lined or blue-tailed skink (*Eumeces fasciatus*) is an active and colorful lizard, somewhat larger than *Anolis.* It will also thrive in a woodland terrarium and may be kept in the same cage with *Anolis.* Its near relative *Eumeces obsoletus,* prefers the drier habitat of a desert terrarium.

The Desert Lizards.

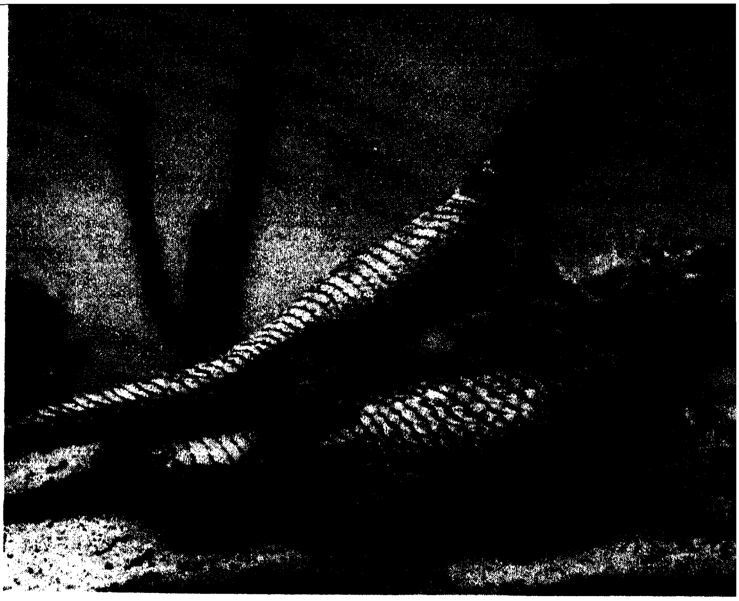
This group includes the brilliantly colored giant collared lizard (*Crotaphytus collaris collaris*), the dragon-like giant collared swift (*Sceloporus poinsetti poinsetti*), the familiar Horned "Toad" (*Phrynosoma sp*), and the poisonous gila monster (*Heloderma suspectum*). All of these larger lizards will live and thrive in a desert terrarium housed in a large glass aquarium tank. The floor of the terrarium should be covered with dry sand to a depth of four inches (for burrowing and to retain heat) and there should be some rocks arranged to form "caves" and similar hiding places. Cacti and other drouth-tolerant plants can be included for a naturalistic effect. A shallow pan of water, its surface flush with the level of the sand should be included. Popular opinion to the contrary, desert animals do drink water and, in captivity, they seem to enjoy bathing in water. Mealworms may be used as a staple diet, varied, of course, by other living insects when they are available.

(*Note.* The gila monster's bite is poisonous—it is the *only* poisonous lizard found in the United States—and care should be used in handling it. It will thrive for long periods on a diet of raw eggs.)

Glass-snake. The glass-snake or legless lizard (*Ophisaurus ventralis*) is a burrowing species which may be kept in either the desert or woodland terrarium. It appreciates warmth and some moisture and may be fed living insects, earthworms, slugs, etc.

Iguana. The "Chinese Dragon" (*Ctenosaura sp*) is the largest American lizard, measuring from 18 to 24 inches in length. Rather rarely seen in the United States, it is common in some parts of Mexico. These tropical lizards require warmth (80° to 85° F.), a humid atmosphere and plenty of water. They may be kept in a glass sided cage or a large and well-planted terrarium. They are quite harmless and we have seen them quite at home in a small greenhouse. Iguanas are omnivorous feeders, eating insects, smaller lizards, tree frogs, snails, worms and fruit.

Right: Adult male and female of the Giant Collared Swift.



Left: Giant Collared Lizard. (Both photographs show specimens in a school terrarium.)

SNAKES

The terrarium for snakes should be large, with sides of glass, or a glass front with the other sides of smooth-finished wood. Wire cages should be avoided because the snakes are likely to injure their noses on the wire mesh. The opening should be large, preferably at the top, to allow freedom in handling specimens as well as for cleaning purposes. Condition in the terrarium should correspond as closely as possible to the natural habitat of the species to be cared for. For example, when keeping garter snakes, blue racers and ground snakes, a woodland terrarium is the best type; for the water snake a semi-aquatic terrarium is best; and the desert-loving species require a desert terrarium.

Snakes love warmth and sunlight but they also spend a great deal of their time in hiding. The terrarium should be placed in a sunny location but should be provided with hiding places made with rocks and sticks. Temperature extremes are harmful to snakes and should be avoided. Temperatures ranging from 65° to 80° F. are usually best.

Plenty of drinking water is necessary and the terrarium should be sprinkled at frequent intervals to provide humidity. Some snakes drink from a dish, other species get water from drops on glass and plants.

Most snakes emit an offensive odor when first handled but drop this habit when they become accustomed to their confined surroundings and to the person who takes care of them. When handling snakes, avoid quick motions. Deliberate unhurried movements are less likely to startle them. Snakes seem to sense a feeling of fear and indecision on the part of the caretaker. Usually a snake can be picked up by holding it in mid-body; but if they are temperamental, pick them up behind the head with the right hand and hold body with the left hand to overcome any thrashing about. It is surprising how easy they are to handle after one becomes accustomed to their movements. Handling snakes after feeding or when they are shedding their skins is poor policy because at these times they may be irritable. Occasionally, a terrarium specimen will "bite the hand that feeds it," but the non-poisonous reptiles inflict only slight wounds.

Snakes will eat a variety of small living animals such as frogs, mice, rats, lizards, fish, tadpoles, earthworms and insects. Some species can be trained to eat dead rats and mice and pieces of raw meat. Garter snakes and bull snakes eat quite regularly and therefore are easily kept in a healthy condition. Other species may be more difficult to feed in captivity and force feeding is sometimes necessary. Force feed only as a last resort because often damage is done to a specimen so handled. Snakes feed best after shedding and plenty of food should be provided at that time.

The most trying time for the captive snake is when shedding its skin. The approach of shedding time can be detected in advance by the dull appearance of the skin and the clouded eyes. At this period the snake is temperamental and may refuse to eat and will strike at anything annoying it. It is advisable not to molest the snake in this condition and to make sure that the humidity is sufficient to prevent the old skin from drying out and adhering to the body. Bathing in warm water lessens such dangers and helps to complete the shedding. Just after shedding the snake is surprisingly beautiful in its colorations and markings.

Snakes are frequently infested with small mites which sometimes, in severe cases, cause death. Infested specimens and their cages should be thoroughly cleaned and dusted with pyrethrum powder. If cuts or open sores appear on the body, they should be washed with warm salt water and treated with Metaphen. Parasites in the mouth are a common ailment and these should be removed. Sore eyes should be washed with a 20% argyrol solution.

When stocking a terrarium with snakes do not crowd the cage with too many specimens. The size of the reptiles should be fairly uniform, large and small should be separated.

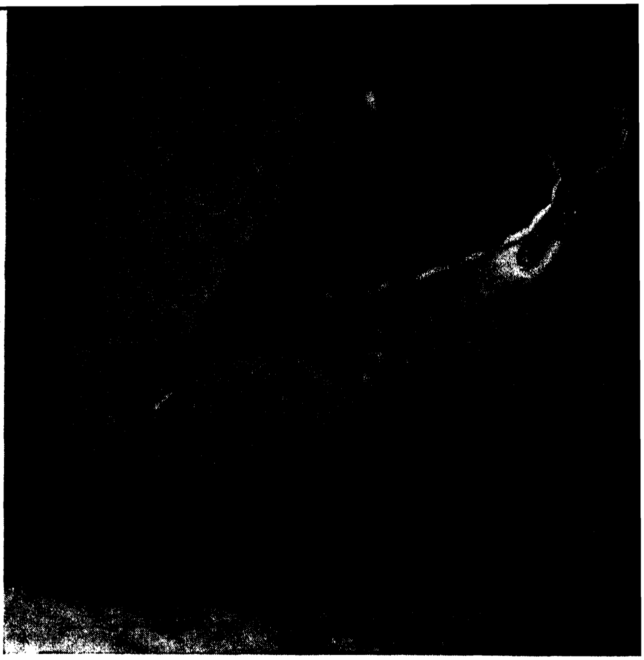
Garter snake. Thamnophis

The garter snake is one of the most suitable snakes for the school laboratory. It is widely distributed and specimens can usually be collected locally. As a laboratory reptile it has few equals because it is easy to handle and does not remain in hiding as do many other species. It will accept food readily and feedings of earthworms, frogs and toads will keep it in a healthy condition. Pregnant females collected in spring and kept in the terrarium and fed regularly will produce living young. The young feed on insects, small earthworms and very small frogs and toads.

Hog-Nosed Snake. Heterodon sp.

The hog-nosed snake is widely distributed, being found in dry sandy regions. It is of small to medium size, has a wide head with turned up nose. This reptile is noted for its odd actions such as feigning death. It is easy to handle, will live in a woodland terrarium and eats small toads and frogs.

Right: Young turtle (Cumberland Terrapin) in an aquarium.



Blue racers and other large snakes

There are some beautifully marked snakes adaptable to the laboratory which are of larger size and which require a good sized terrarium. Included in this group are the blue racers, black snakes, king snakes, bull snakes and milk snakes. On the whole these are all mildly mannered specimens and this applies particularly to the king snakes and milk snakes; but the blue racers, black snakes and bull snakes are nervous until they become accustomed to their cages. Living rats, mice and frogs are the best food for this group.

Water snake—Natrix

The common water snake will be at home in a semi-aquatic terrarium. It is often a bad tempered snake and should be handled carefully. Fish, tadpoles and frogs are needed for its diet.

Poisonous species

We do not advise the keeping of poisonous snakes in a school laboratory. If the necessary equipment is available and if such specimens are to be kept they should be in charge of a competent adult and the utmost care should be taken when handling members of this group. The woodland terrarium will be satisfactory for the copper head; the water moccasin will enjoy a semi-aquatic tank; and the rattlesnake will find the desert terrarium to its liking. Rats, mice, frogs, toads and fish should supply the necessary food.

TURTLES

Turtles are interesting reptiles and, quite aside from their usefulness in anatomical and physiological studies, they are well worth studying in the aquarium and terrarium. Most of our native turtles are aquatic, but several species are terrestrial and the two groups must be cared for in different ways.

Aquatic Turtles. Large turtles intended for physiological and anatomical studies are usually aquatic, the Cumberland terrapin, *Pseudemys elegans,* being used in great numbers. If these large-sized turtles are to be kept in considerable numbers a wooden pen or tank of generous dimensions will be required. For permanence, the tank should be constructed of cypress, although galvanized metal will do. The floor should have a gradual slope with water a foot or eighteen inches deep at one end and "dry land" at the other end. Drains should be so located that the tank can be flushed out and kept clean with a minimum of effort.

However, most teachers are interested in keeping only a few living turtles in the laboratory and specimens of small size are usually selected. Baby turtles of terrapin *(Pseudemys),* painted turtles *(Chrysemys)* and the soft-shelled turtle *(Amyda)* are all suitable and young snappers *(Chelydra)* are also interesting. All of these turtles are aquatic, but all should be kept in a semi-aquatic habitat. If you have a large aquarium tank, let a mound of rocks project up above the water line at one end. Large rocks are perhaps better as there is less likelihood of turtles moving them and becoming injured. Should this type of cage not be available one may be constructed of wood with a water container in the center flush with the floor level. Even here, there should be a large rock or so in the water basin to aid the turtle in climbing out at will. Any turtle cage should be so located that it receives some sunlight daily, but in glass cages some means should be afforded the animals of escape from the strong sun's rays if the interior should become too hot.

Aquatic turtles feed mostly upon fish and meat with a little vegetable matter as well. Their diet may be varied to include clams, earthworms, mealworms, canned salmon and shrimp. Feed as much as they will consume daily. Wash the cage out after feeding, lest the water become foul. Because of excrement and other wastes, it is well to clean the turtle cage out at least daily—never let any offensive odors develop.

Most of the turtles of our northern states hibernate at the onset of cold weather. Even though yours may be kept in a heated schoolroom, it will be induced to hibernate or become quite sluggish due to low temperatures when the building cools off at night. It is therefore not uncommon for turtles to go on extended hunger strikes, refusing all food for months. It does no good to attempt to force feed. Some simply place them in a cool dark corner and allow them to sleep, disturbing them occasionally to bathe them in warm water. If the animal becomes alert enough to take food, let it eat, but more often than not it will refuse.

If an animal is merely in a sluggish condition it will frequently enjoy a "sunshine bath" in winter, made possible by hanging an electric light bulb a few inches over it. This often brings about eating when it seems to be futile to attempt it otherwise. In many cases, turtles will remain quite active throughout the winter months if the water in their tank is kept warm (75° to 80° F.) both day and night and if they receive a few hours of natural sunshine each day.

Terrestrial Turtles. The common box turtle *(Terrapene carolina carolina)*, often called wood tortoise, is a land species frequenting moist woodlands. It lives very well in a planted woodland terrarium containing a shallow pan of drinking water. Box turtles accept a great variety of food, eating mushrooms, insects, earthworms, slugs, snails, apples, bananas and meat. The gopher tortoise *(Gopherus polyphemus)* is another terrestrial form which frequents dry and rather sandy locations. It may be kept in a rather dry terrarium of the "desert type," but, like the box turtle, it should be provided with drinking water. It is largely vegetarian in its feeding habits, eating grass, fruit, lettuce and cabbage leaves, celery, carrots, etc.

AVES

BIRDS

Most of our native birds are protected by both State and Federal laws and cannot be captured nor maintained in captivity without special permits. Blue Jays, Crows, Blackbirds, Starlings, some kinds of Hawks and Owls, and a few other species are unprotected, but most of these are difficult to maintain and are not particularly suitable for laboratory study.

On the other hand, Canaries, Ring-necked Doves, Parrakeets, Zebra Finches and many other semi-domesticated cage birds are easily cared for and furnish very interesting study material.

Cages. Although Canaries and some of the smaller finches will tolerate very small cages, large cages are much more desirable, and are also necessary if breeding and nest building are to be observed. In order to reduce the danger of cold drafts, one entire side of the cage and the lower halves of the three remaining sides should be of some solid material (wood, metal or glass), rather than of screening. Such cages may be purchased, but it is a simple matter to make them, using wood, glass and ordinary fine-meshed metal screening. The lower part of the cage should be so constructed that the floor can be conveniently cleaned and this, of course, should be done every day.

For canaries and other birds of that size, a flight and breeding cage should measure about 24 inches deep, 30 to 36 inches long and 36 to 48 inches high. Parrakeets and doves should be provided with a cage at least half again as large.

Foods. Prepared bird-seed mixtures are available for canaries and most other birds commonly kept in cages, and the "mockingbird food" used for soft-billed species is also sold by bird dealers. In addition to prepared foods, most birds will relish fruits of various kinds, lettuce leaves, celery tops, cottage cheese, bread and hard-boiled eggs. Seed-eating birds enjoy an occasional lot of wild grass and weed seeds. Live insects should also be provided and living mealworms are a staple food for soft-billed birds.

Sand and gritty gravel and abundant bathing and drinking water should be kept in the cage at all times.

MAMMALIA

ARMADILLO

The Nine-banded Armadillo is the species usually furnished on our orders, and these are secured by our collectors in the hilly regions of Southwestern Texas.

These animals possess amazing strength both in their legs and tails. The cage in which the armadillo is to be kept must, therefore, be built accordingly of wire which cannot be torn easily. Do *not use* screen wire nor "chicken wire." Instead, use a good grade galvanized mesh wire, commonly called "hardware cloth," and the mesh should not be too large, say, about ¼ inch. The cage must be roomy. The supporting framework for the wire should be sturdy—if of wood, of 2"x4" stock—angle iron perhaps being preferable if it can be afforded. Hinges, door, latch, etc., must be of suitable weight.

The inside of the cage should contain a smaller "house" in which the animal may retreat during the day for sleep—being normally a nocturnal creature. Food receptacles should be kept out in the open where they can be cleaned more easily. Cover over the entire "pen" with a heavy bed of oat straw, hay, excelsior or large wood shavings. The bedding material should not be too dusty, as the animal will burrow in it.

Keep clean water before the animal at all times—in a suitable sized heavy walled vessel. Food should be available each evening. Naturally, the armadillo feeds upon all kinds of worms, insects, and tender roots and some carrion. In captivity, they may be fed the following diet, which may be varied slightly:

6 ounces milk (being composed of 3 ounces condensed milk and 3 ounces water)
1 small banana mashed
⅛ pound ground lean beef
1 raw egg.

Mix above thoroughly and feed as much as the animal will take at one time.

If any insects are available, they may be added to the food. If beef blood is available, some of this may be given at times to vary the diet.

OPOSSUM. *(Didelphis virginiana)*

The opossum is a marsupial and one of the most interesting native American mammals. It can be kept in a laboratory cage for study and observation, although research workers who maintain breeding stocks report that outdoor cages with fairly large runways are required. An indoor cage should be at least four feet square and constructed of *heavy* wire screening. A small covered box inside the cage should be provided for a sleeping compartment. The floor of the cage should be covered with straw or wood shavings and cleaned every day.

Opossums normally feed upon insects, frogs, toads, salamanders, lizards, and a relatively large amount of carrion. They will also feed upon ripe fruit which falls to the ground. In fact, there is the old southern adage that the opossum is not good to eat until it has had access for quite some time to the ripe persimmons which grow abundantly in certain sections of the South. Whether they are good as food even then is questionable in the minds of many people in the same region. In captivity, then, the animals are fed milk, eggs, lean beef, beef liver, and the like. They will consume ordinary "table scraps" but such a diet must be supplemented. McCrady (*Embryology of the Opossum*, published by the Wistar Institute) points out that, if opossums are to be kept in good condition for long periods of time and especially if one hopes to breed them, they must be given liberal amounts of bone meal with other foods daily. He also points out that exercise is a prerequisite to breeding and that this will hardly be had unless the pens have at least 50 square feet of floor space.

GUINEA-PIGS

The guinea-pig is a rodent which was native to South America, but which has enjoyed a world-wide distribution due to its great desirability as a laboratory specimen. It is a docile animal, prolific, its care is not exacting, and it has many uses, either in the hospital laboratory or in courses in zoology and parasitology in colleges.

Cages similar to those used for rats, but larger, are required. They must be of wire mesh construction in order to permit of thorough cleaning. The solid and liquid wastes from these animals will give rise to considerable odors if the cages are not given attention daily. The bottom of the cage, or one corner, may be covered over with a bed of straw, provided this is changed frequently. Keep animals at average room temperatures, about 72° F. and out of all drafts. A thoroughly dependable diet is that composed of a mixture of grains, such as corn, oats, and wheat with succulent vegetables and alfalfa hay. The succulent constituents must be emphasized for the animals do not require water when greens are available. Fresh grass, many fleshy weeds, lettuce leaves, cabbage, carrots, sweet potatoes, and the like should be on hand at all times. Then, too, the guinea-pigs relish the prepared food pellets sold by Turtox as No. 55V32. Only greens and vegetables are required in addition. (Refer to section on *White Rats* and to the Turtox Booklet, "Laboratory Experiments in Nutrition," for additional information on diets.)

Only the larger, better developed individuals should be bred. Allow both sexes to become fully mature before breeding so that better litters will be produced. The male may be allowed to remain in the cage with the pregnant female if there is ample room; but, if other cages are available, it would in many cases be better to separate them. The young begin to eat solid food when quite young so that tender leafy vegetables should be placed before them a day or so after birth. The young guinea-pig is strikingly well developed at birth and can shift for itself at an early age. Do not remove it from the mother until it is well able to eat grain or prepared pellets in addition to the greens.

The guinea-pig is used very commonly in heredity experiments. Line-bred animals are available from Turtox. Guinea-pigs are especially recommended in elementary studies on

White Rats are most interesting pets and they are extremely useful in nutrition experiments.

reproduction as their care is so simple and they may be handled by the students, who will become quite fond of them.

Guinea-pigs, like other laboratory animals, sometimes have external parasites and this can be detected by their scratching. Dust them with pyrethrum powder (available from your local drug store) occasionally. The cage should be dusted with it liberally also in addition to having a frequent cleaning. Sterilize it if possible in boiling water or wash it with a strong solution of ammonia. Rinse and dry thoroughly before replacing animals. Any straw or bedding should be burned.

WHITE RATS

The albino rat has long been used in anatomical, physiological, and even in psychological experimental work and, because so many data are available, it is generally considered a standard test animal. In considering it for nutrition tests, we find it to possess many laboratory virtues and no serious handicaps, hence its almost universal choice.

Animals intended for experimental or demonstration purposes should be kept in cages having a wire bottom which will permit the passage of urine and feces into the pan beneath the cage. Unless this provision is made, a very unsanitary condition will result and this will be detrimental to the animals and offensive to those conducting the experiments. Cages must be kept immaculately clean, it being highly advisable to disinfect them (as well as other equipment) *at least* weekly. It is a common practice to carry out this procedure daily. Do not allow the cages to remain in a drafty place or where direct sunlight will fall upon them for any length of time. The animals must receive sunlight, but in the form of diffused radiation.

The rats must have at all times a plentiful food and water supply, particularly the latter since the stomach of the animal is so small that it requires water at frequent intervals. The water may be either distilled or tap, except in the case of a quantitative experiment, where the former is essential. A sanitary drinking fountain should be placed in each cage. When the animals are not being used in an experiment, the diet should be a well-balanced one, and that listed on the following page is excellent. It comes ready for use and includes all of the important food elements, although it is a good practice to supplement it with some succulent vegetables such as carrots and lettuce. The rat is an omnivorous creature and will eat practically any human food so that one need have but little difficulty in keeping them on a sustaining or growing diet. The cage should be provided with special food cups.

Rats, under good conditions, may live for as long as three years. At about eighty days of age, the female can be mated, although it is better to wait until she is somewhat older. The gestation period is twenty-one days, subject to slight variation. Females usually mate soon after giving birth to a litter unless the male is removed. The male can be left with the pregnant female and his presence in the cage with a new-born litter is desirable unless the second mating is not wanted. However, it is sometimes better to give the pregnant female a cage of her own, made of not larger than ¼-inch mesh wire screening. Over-excitement, physical strain, or the presence of other rats (male or female) sometimes causes the mother to kill her litter. The young rats may remain with the mother (even if pregnant) up to about the time the new litter is expected or for about twenty-eight days if another pregnancy has not occurred.

Gentleness is the rule in handling white rats. Should you wish to observe an animal carefully, grasp it firmly, but not quickly, by the middle of the tail, elevate the arm and let the animal rest on your other hand. Always refrain from jerky or rapid movements in handling these animals, lest they become frightened. The simplest rule in handling any experimental animal is that it be done in a kind manner. Use only cage bred animals, which are usually very gentle.

Diets. The No. 55V30 Turtox Rat Growing Ration is a ready mixed complete diet for growing animals; it sells for $2.50 per five-pound package. A similar diet can be made up of the following ingredients:

Yellow cornmeal	76 parts
Gluten flour	20 parts
Sodium chloride	1 part
Calcium carbonate	3 parts

Viosterol, 20 drops per 1000 grams of diet.

WHITE MICE

Mice may be handled and cared for by the same methods as those used for white rats, and they may be fed the same diets. They may be kept in smaller cages (of fine-meshed wire) or in battery jars with wire screening tops.

Nutrition Experiments and special deficiency diets are fully explained and illustrated in Turtox Service Leaflet No. 49, "Nutrition Experiments," (free), and in "Laboratory Experiments in Nutrition," an illustrated booklet published by Turtox and sold at $1.00 per copy.

BATS

It is occasionally desirable to keep living bats in a laboratory cage and in some instances considerable numbers of them must be maintained for research purposes. They should be kept in a rather large, well ventilated cage, inside of which there should be a small box in which they can hide during the day. The latter should contain a few cross bars to which they can cling easily. A flying cage (6'x4' or larger) is very desirable if bats are to be kept for long periods; such a cage can be constructed of a light wooden framework covered with wire screening.

Dr. W. H. Gates of Louisiana State University has had much experience in feeding captive bats (See *Science* for May 15, 1936, page 8 of supplement.) and reports that they have been fed upon cheese, yeast, minced bees, minced insects of other kinds, bread, crackers, hard boiled eggs, any kind of vegetable, unsalted meat, or milk. He indicates that they prefer cottage cheese above all other artificial foods and bees above other insects. Any food has to be chopped extremely fine and should be given to them in quite shallow dishes. Remember to keep clean drinking water before them at all times.

The cages should be kept perfectly clean at all times. As opportunity is afforded, examine them for external parasites.

GOLDEN HAMSTER

The Golden Hamster is a small rodent native to parts of Europe and Asia. It is about the size of a large mouse (2½ to 4 ounces), has a short tail, and large cheek pouches. The Hamster is valuable for breeding experiments because its gestation period is very short (16 days) and there are from six to ten young in a litter.

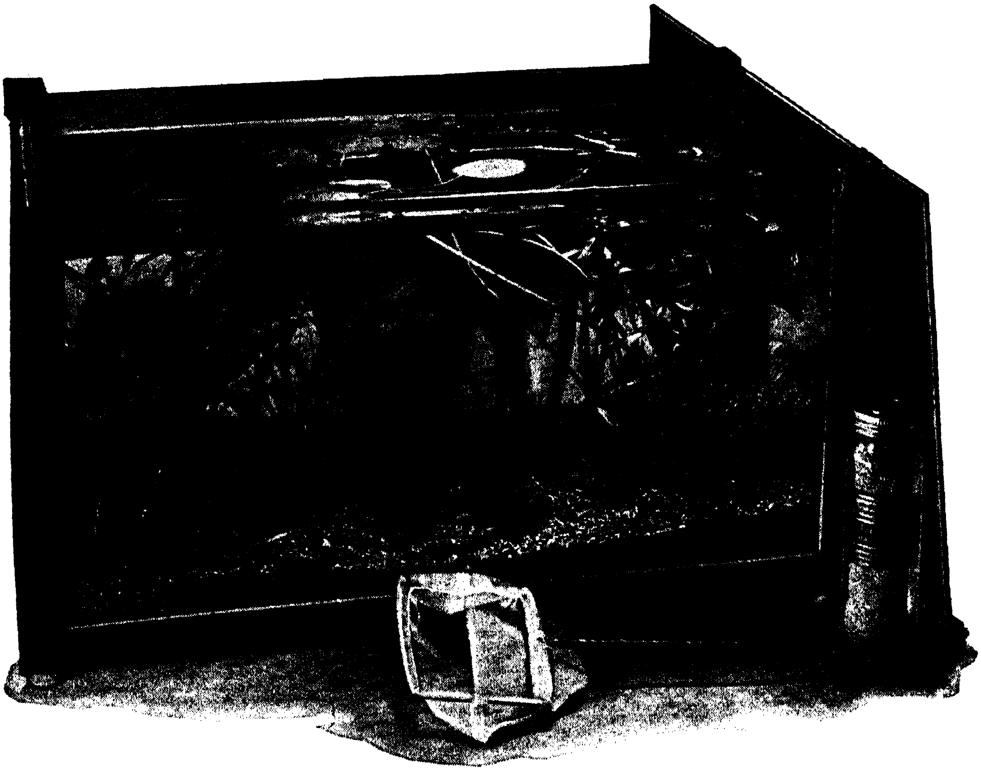
The diet for this animal is quite varied—it thrives upon grain of all types and will also feed upon bread, prepared foods (such as might be available for rats, mice and guinea pigs), sweet and Irish potatoes, various succulent vegetables and the like. These animals should be fed at least three times a week and at each feeding be given more than is eaten promptly, because they like to hoard food in their nests and eat it when they desire. A source of clean water should be available and clean straw, hay and excelsior may be used as nesting material.

Hamsters will bite upon provocation or excitement, but they are easily tamed and may be handled with relative safety. They make interesting laboratory pets, altho they are nocturnal in most of their activities and spend most of the daytime asleep.

Cages for the Hamsters should be made of strong, fine-meshed metal screening, for they will readily gnaw thru a wooden container. The cage should be provided with a small covered box for a nest (the Hamsters want a dark place for their nests) and some soft material for nest-making. The cage should be located in a warm place (72° to 80°F.) and sheltered from drafts.

Appendix

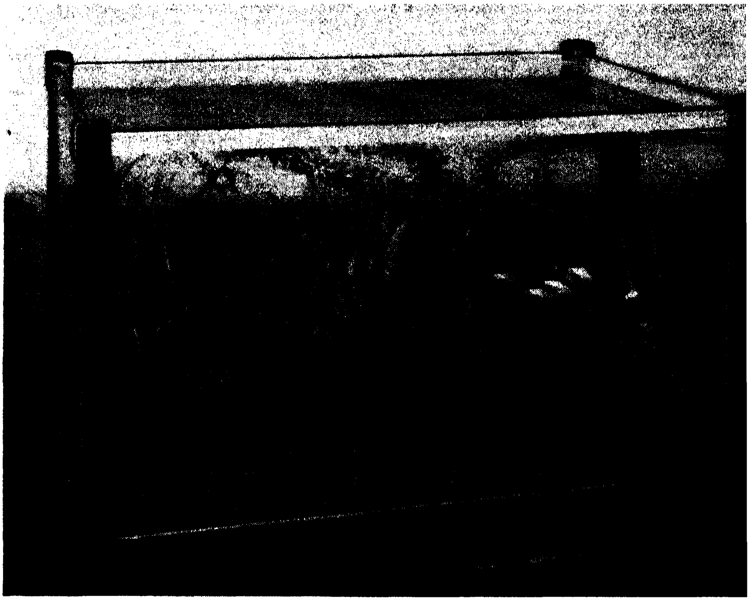
THE BALANCED FRESH-WATER AQUARIUM



A balanced fresh-water aquarium housed in a six-gallon tank. This photograph was taken about ten days after the aquarium had been planted.

Starting and maintaining a balanced aquarium in the school laboratory is easily accomplished by anyone who is willing to devote a little thought and care to the work. The pleasure and practical teaching advantages to be derived from one or more perfectly balanced aquaria, containing interesting plant and animal specimens, is well worth the time and effort expended. Before starting your aquarium, however, make sure that you have the correct type of tank, the right quantities of aquatic plants and animals and, of greatest importance, be certain that you are familiar with the essential but simple biological laws which govern the "balancing" of all fresh-water plant and animal associations. For a balanced aquarium is, of course, merely a biological association of plant and animal forms.

Right: In this aquarium arrangement, pieces of slate have been used to create a naturalistic rock ledge.



The following brief outline states the procedure to follow in establishing a balanced aquarium. If these directions are followed closely, no particular difficulty should be encountered.

Equipment. The only absolutely essential piece of equipment is a suitable aquarium tank; a rectangular tank with metal frame, glass ends and sides, of about 6 to 9 gallon capacity is recommended. Small, round aquaria are not so satisfactory (visibility is poor through curved glass), and the round fish globes are useless. In addition to a suitable tank, the following items will prove their usefulness: dip-net for transferring fish, one pair of long aquarium forceps, one pair of plant snips, and a syphon tube.

1. Clean the tank thoroughly, removing all dust, grease, etc. from the glass. If the tank has previously been used as an aquarium, wash very thoroughly with soap and ammonia water. Rinse with clear water three or four times.

2. Clean thoroughly, in *running water,* sufficient aquarium sand or gravel to cover the bottom of the tank to a depth of one to two inches. Continue washing the sand until all debris and soluble matter has been removed. Place the sand in the aquarium.

3. Now add the water. Use clear pond water if possible; if this cannot be obtained, use tap water which has stood in open containers for a day or so. Pour the water into the aquarium until it is 6 or 8 inches deep. After it has been planted, add more water to fill the aquarium.

4. The aquarium should be placed where it will be exposed to strong diffused light. Direct sunlight for an hour or so each day is usually not harmful, but neither is it necessary. North or east exposures are usually best.

5. The aquarium is now ready for planting. Plants in an aquarium serve biological (and chemical) purposes; first, they produce oxygen, which the animal forms require, and, second, they make use of the carbon dioxide and other excreta thrown off by the fishes and other animals. A balanced aquarium with sufficient plant life is always properly aerated; the water need never be changed.

It is well to use plants rather sparingly at first, remembering that they will soon grow and spread. If too many are crowded in at the beginning, some may die and decay, thereby fouling the water. All kinds of plants will not thrive in an aquarium and it is best to secure tank-grown (not wild) aquatic plants of kinds that are known to grow well in aquaria. *Vallisneria, Sagittaria, Elodea (Anacharis), Myriophyllum* and *Cabomba* are all good. Many other plants can be grown successfully in an aquarium, but the ones mentioned give variety and are dependable.

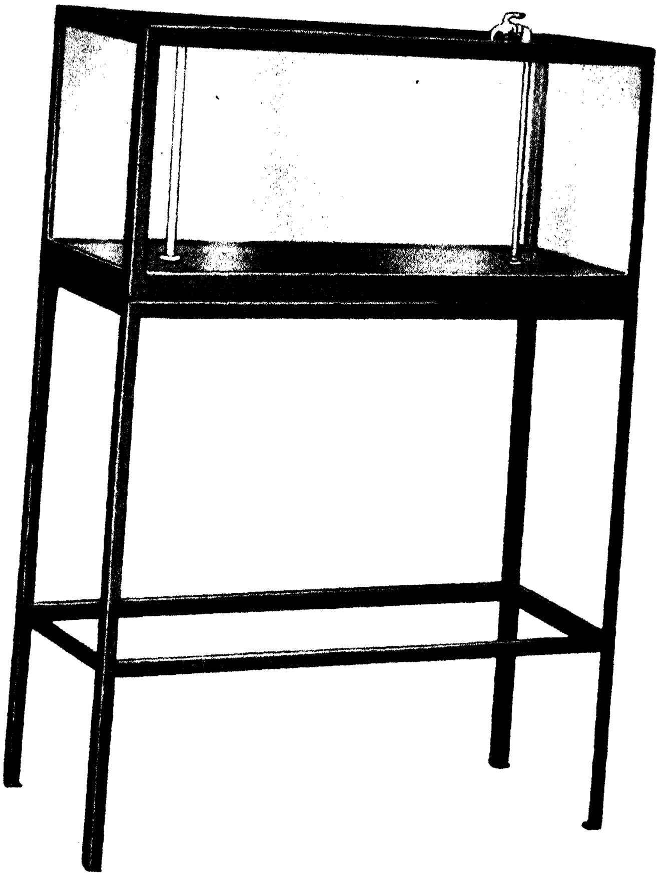
6. Plant the aquarium as follows: Take several of the rooted plants (such as *Vallisneria* and *Sagittaria),* spread the roots out on the sand and cover them up to the crowns, pressing them down to secure anchorage. Add several stalks of the non-rooted plants *(Elodea, Myriophyllum,* and *Cabomba),* weighting the lower ends down with small stones or with pieces of lead. Arrange the upper parts of the plants so that they float freely in the water, and remove all dead or broken leaves. Now fill the aquarium with water to within one inch of the top.

If the conditions are right, growth should be noticeable in about two weeks after planting. If the water does not become clear in two or three days, it is usually an indication that it contains some dead and decaying plants or other organic matter.

7. Allow the aquarium to stand for a few days until the water has cleared, when it will be ready for its animal population. (Snails, fishes, etc. can be placed in the aquarium immediately after planting if necessary, but it is best to wait until the water is clear.)

8. In stocking an aquarium, several things must be borne in mind. First, use only animals which get along together; predaceous forms must be kept by themselves. Second, do not use animals (or plants) which naturally live only in running water, as they will not live in the close confinement of an aquarium. Third, do not overcrowd. Fourth, do not use animals which will stir up the sand on the bottom and keep the water cloudy.

The so-called fish capacity rule is: one inch of fish to one gallon of water. The average 6-gallon tank will support 6 inches of fish—i.e., three 2-inch or six 1-inch fish. This rule, of course, is merely approximate. The number of fish used must be governed by the abundance of the plant growth and the number of other



A good type of medium-sized tank for a running water aquarium. Such tanks may be purchased with or without iron stands.

animals which remove oxygen from the water. It is usually advisable to use several small fish rather than one large one. Small native fishes (minnows, dace, bullheads, and sunfish) and the brilliantly colored tropicals are more interesting than the sluggish goldfish. (If fish are not used, snails, aquatic insects, and crustaceans will add much life and interest to the aquarium.)

Snails, clams, and newts are commonly used in the balanced aquarium. Snails are valuable as scavengers, and six to a dozen may be kept in a 6-gallon tank. Both egg-laying and live-bearing (viviparous) snails are desirable. One clam, 1 to 2 inches long, is sufficient for a 6-gallon aquarium. Several small newts may be kept in the balanced aquarium in addition to a normal quota of fish and snails.

9. Watch the aquarium carefully for the first few weeks. Remove at once any dead animals and clip off all dead parts of plants. After the plants have become established, it may be necessary to cut back or remove some of them to prevent excessive growth.

RUNNING WATER AQUARIA

Some animal forms are best kept in running water tanks, but such an arrangement requires considerable equipment. In general, the tanks used for running water aquaria should be of rather large capacity, twenty to one hundred gallons or more. The tanks should be equipped with double out-flow pipes (each with strainer) to reduce the likelihood of clogging and overflowing. If the water flow is slow (and this is best in most cases), running-water tanks can contain sand or gravel and growing plants.

The source of the water is of great importance. Lake or river water is best and water from deep artesian wells is least desirable. Water treated with chlorine or other chemicals used for purifying city drinking water is not suitable and can be used only if it first passes through a special aerating tank.

Marine aquaria equipped for running sea-water are practical only in the larger sea-coast laboratories. Adequate pumping facilities and gravity tanks must be provided and it is desirable that the salt water pass through lead or glass pipes. Small marine aquaria such as are used in most inland laboratories make use of the initial supply of sea-water, aerating it continually and adding distilled water as needed to replace that lost by evaporation.

MARINE AQUARIA

I The Cold-Water Marine Aquarium

Most of the following notes apply to both cold-water and warm-water marine forms. Some warm-water animals, and especially the tropical coral-reef fishes, demand special temperature requirements, and teachers interested in such specimens are referred to the discussion of *Tropical Marine Aquaria.*

The biology student living on the sea-coast has a great advantage over his fellow in an inland laboratory, for there can be no comparison made between the interest-arousing qualities of a dead starfish dripping with and smelling of formalin and those of a living starfish crawling over the submerged rocks in a clear tide-pool. There is no reason, however, why students living far from the sea-coast should not have the opportunity of seeing living examples of some of the smaller marine animals. Salt-water aquaria are now used in hundreds of inland schools and the living marine animals can be shipped successfully at any time during the colder months of the year.

Collecting and Shipping. Teachers who are fortunate enough to live near the seashore are usually able to collect an interesting variety of living marine animals at any season of the year, and, if the school laboratory is located nearby, the transportation of the specimens presents no problems. Wooden or enameled pails are best for use in marine collecting, and, of course, glass jars of various sizes are suitable for small forms. (Do not use metal containers.) Collect small-sized specimens and do not crowd too many into a small amount of sea-water. It is far better to return to the laboratory with one small starfish alive than with a pail-full of dead or dying specimens.

Inland schools must ordinarily order their living marine specimens from a seacoast collector and, for many years, Turtox has offered this service during the cooler months of the year. Most shipments are made from our Massachusetts coast station, although we also have facilities for shipping from the Pacific Coast and from several points in Florida. The best type of container for shipping living marine forms is the regular wooden fish-tub. The extra sea-water which must accompany most shipments is sent in five-gallon or ten-gallon glass carboys.

The Aquarium Tank. The best container for a small marine aquarium is a rectangular all-glass tank, although the standard metal-framed tanks with slate bottoms and glass sides may be used provided they are so constructed that no water comes into direct contact with any metal parts. (Turtox metal-framed tanks are so constructed.) The best size for a beginner is a tank of from six- to ten-gallons capacity. After one has had some experience with a small aquarium, the larger sizes may be used.

The tank or tanks to be used should be thoroughly cleaned and made ready *before* the shipment of sea-water and living specimens arrives. The tanks should be located in a place where a fairly low temperature can be maintained and where they will receive little or no direct sunlight.

It is a good idea to divide the shipment of sea-water and living specimens between two tanks. This allows one to determine which animals will live together in harmony and, should any forms be injured, they may be kept in a separate aquarium until they recover.

Sand. Ocean sand is desirable for certain of the burrowing forms. However, sand is not essential and may be omitted from the smaller aquaria. If you use sand other than that secured from an ocean beach, be sure that it is a pure silica sand and wash it *thoroughly and repeatedly* to remove any mud or organic matter before it is placed in your aquarium.

Sea-water. Natural salt-water from the ocean is supplied with our aquarium sets and we do not advise the use of synthetic sea-water unless large quantities are required. However, some teachers will find it economical to prepare synthetic sea-water and, in such instances, the following formula may be used:

Distilled (or rain) water	10 gal.
Sodium chloride	45½ oz.
Potassium chloride	1¼ oz.
Calcium chloride	2 oz.
Magnesium chloride (dry)	8¾ oz.
Magnesium sulphate	11½ oz.
Bicarbonate of soda	1/5 oz.

After thoroughly mixing the above, add:

Potassium nitrate	1/5 oz.
Sodium phosphate	10 grains

A small (6-gallon) marine aquarium containing starfish, sea urchins, anemones, mollusks and coral. Salt-water aquaria like this are now used in hundreds of inland schools.

Iron chloride	5 grains
Natural sea-water	1 gal.

(*Note:* Technical or U. S. P. chemicals are better than the C. P. grade for this purpose.)

The reason for adding the natural sea-water is not entirely clear; but it is unquestionably necessary. Some vital elements are apparently lacking in the manufactured sea-water and the addition of the natural water remedies this. It has been suggested that natural sea-water contains substances corresponding roughly to the vitamins in foods.

After the synthetic sea-water has been made up, it should be placed in tightly corked glass carboys and kept in a dark cool place until wanted for use.

Maintaining the Right Concentration. When the tank is filled with sea-water, the level of the water should be marked on the outside of the glass by drawing a line to coincide with the surface of the water. As evaporation takes place, pure distilled water should be added to bring the water up to the original level. In large tanks, the water should be tested from time to time to see if distilled water is needed to replace that lost by evaporation. Natural sea-water should show a reading of 1.025 when tested with a hydrometer. Any needed adjustment should be made weekly or oftener.

Temperature of the Water. The proper temperature control is of utmost importance in the success of a marine aquarium. In general, the water temperature should be maintained at *55° to 60° F and a temperature ten degrees lower than that is often better.*

Sudden changes of temperature are usually fatal to aquatic animals. If your shipment of living marine animals arrives during the winter when the weather is cold, the temperature of the sea water in their container will probably be very little above 32° F. This should be raised very *gradually* and, in no case, should the animals be transferred suddenly to much warmer water. A good plan is to allow a period of at least 24 hours in which to allow the temperature of the water to rise gradually.

Many suggestions have been offered in regard to the matter of keeping the school marine aquarium water cool; but the one considered most feasible is that in which the aquarium is placed on the window sill where it will not receive direct sunlight. The window is then opened until about two or three inches of the glass side of the aquarium are exposed to the out-of-door conditions. The open space on either side of the tank is then blocked off with wooden panels and strips of felt so that the room temperature will not be affected. The advantage of such a system as this is that it is possible to maintain a much lower degree of temperature in the aquarium than could otherwise be attained.

Tropical forms must, of course, be provided for according to the temperature conditions found in the water where they are collected. Many of the coral-reef fishes must have a water temperature of 70° to 85° F.

Aeration of the Water. The first and most important rule to follow in planning salt-water aquaria is to remember that most marine animals require more oxygen than do most fresh-water forms.

The main reason for this is that the marine forms used in aquaria are usually collected in tide-pools along surf-swept beaches where the oxygen content of the water is unusually high. Therefore, fewer inhabitants should be placed in each tank than would be the case if one were dealing with fresh-water animals. The tendency is always to overcrowd an aquarium and, although this may cause eventual failure of a fresh-water tank, it is quickly and completely fatal in a salt-water aquarium.

Large public exhibition aquaria are usually planned so that there is a large reservoir of salt-water furnishing enough water for a continuous, though rather slow, flow through the exhibition tanks. Compressed air vents are usually placed so that the water is aerated thoroughly while in the main storage reservoir. However, the size and cost of such a system as this renders it impossible for the average school laboratory.

Several small and inexpensive aerating pumps are now available and one of these will be of great help in aerating the water in your aquarium, especially during the first week or so until the animals become "acclimated" to their new surroundings. (Turtox will furnish information and prices on suitable aerators for any size tank.)

Theoretically a marine aquarium may be "balanced" just as a fresh-water aquarium is, but in actual practice this is seldom possible. Diatoms and the green alga, *Ulva*, produce some oxygen, but in most marine aquaria the oxygen used by the animals is greatly in excess of that produced by the plants and a "balance" is rarely possible. Because of this condition, the mechanical aeration of the water in a salt-water aquarium is highly important.

Light. Salt-water aquaria require much less light than do fresh-water aquaria and they should receive little or no direct sunlight. Except when it is desirable to watch the inhabitants, the aquarium should be shielded by cardboard on three sides to keep out very strong light.

The Animals. With the aquarium tank made ready and in its permanent location, the preliminary preparations are completed and the living marine animals may be ordered. Under the ideal conditions existing in very large aquaria, almost any marine forms will live; but the marine-aquarium enthusiast who is experimenting with small tanks should attempt to secure the more hardy animals which will live for a while, at least, under somewhat adverse conditions. Among the best small-aquarium inhabitants are small marine snails and barnacles. Starfish, sea urchins, sea cucumbers and sea anemones will usually live for a few weeks and, under carefully controlled conditions, may be kept in aquaria for much longer periods. Small crabs will often thrive where more exacting forms die.

Dr. Lyell J. Thomas, who has done some very interesting work with marine aquaria at the Zoologica Laboratory of The University of Illinois, lists the following animals which have been found to do well in smal marine aquaria under laboratory conditions:

"Protozoa—a long list has been identified and offers the inland protozoologist a new and fertile field fo study; Porifera—silicon sponges; Coelenterata—Obelia, Clava, Sea Anemones, Corals; Platyhelminthes—Small Turbellarians found on Ulva; Nemathelminthes—free living; Rotifera; Bryozoa; Annelida—Serpulids or tube worms, Nereis, Clymenella; Mollusca—Snails, Limpets, the nudibranch Aeolis, Clams (both Mytilus and burrowing forms), Pecten, Chitons; Arthropoda—Barnacles and many small Crustacea; Chordata—Ascidians; al coming from pool or low tide areas."

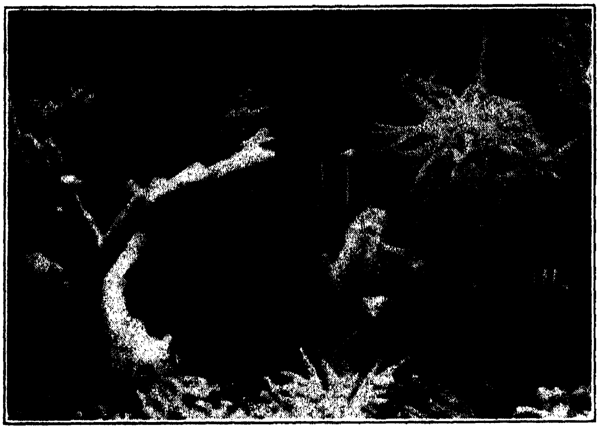
Feeding the Animals. To feed the animals, it is sometimes best to remove them to a separate dish filled with salt-water of the same temperature as that of the aquarium. Wooden forceps are best for handling the animals. Twice a week is often enough to feed the various forms. Small pieces of macerated oysters, clams, or fish make a fine food and they should be dropped near the mouth of the animal by means of forceps. The juice of oysters and clams also makes a fine food and can be dropped by means of a pipette into the mouths of such animals as the *Metridium, Thyone,* and *Cucumaria.* Fresh-water clams may be used as well as salt-water clams and even small pieces of fresh-water fish will be readily devoured. As soon as the animals have been fed, they may be returned to the aquarium and the glass plate put back on top of the tank.

Starfish should be provided with small living clams, oysters, and snails, upon which they will feed. They usually refuse other food.

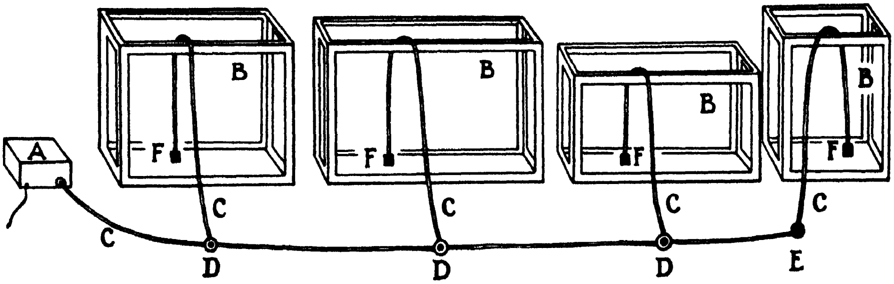
If you wish to feed the animals without removing them from the main tank (and this is advisable, of course, in many cases), put in very small amounts of food and remove promptly any that is not eaten, or otherwise it will decompose and quickly foul the aquarium.

Temporary Marine Aquaria. Even though it may require considerable effort to maintain salt-water aquaria for long periods of time in a small laboratory, the teacher will find that a few attempts along this line are well worth while. The tanks containing sea-water can be maintained throughout the school year and, from time to time, assortments of a few living marine forms can be ordered. Even though some animals are short-lived, the students will have had an opportunity to study living starfish, sea urchins, anemones, and other marine forms which they might otherwise never have seen. The result of even a few hours spent in this way will be a real interest that preserved specimens could never have awakened.

Summary. The really essential points to keep in mind are few; but they are ***very important:*** (1) Use small specimens and few of them; (2) Keep the water temperature low; (3) Aerate the water, and (4) Feed sparingly. The Turtox Service Department will gladly answer your questions and offer help in the establishing and caring for marine aquaria of any size. Write to us if there are any points on which you wish additional information.



Coral-reef fishes and other warm water forms in a tropical marine aquarium.



Method of aerating several tanks with one air pump. A, air pump. B, aquarium tanks. C, rubber tubing. D, adjustable three-way regulator valves. E, adjustable two-way valve. F, air breakers.

II The Tropical Marine Aquarium

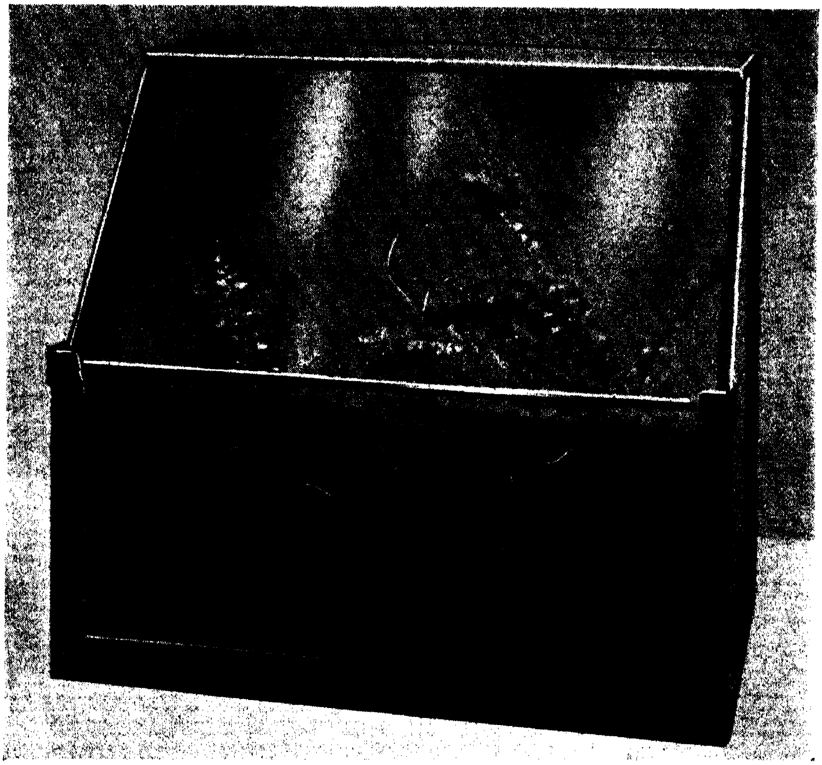
Tropical forms such as the brilliantly colored coral-reef fishes, sea-horses, octopi, southern starfishes, sea anemones, etc. will thrive in marine aquaria if they receive proper attention. The water in which they are kept must be well aerated (this is even more important in the case of tropicals than it is for cold-water forms), the water temperature must be kept at the correct point, and they must be fed oftener than cold-water marine animals.

Care upon Arrival. If you purchase tropical marine specimens, they will probably be shipped to you via express in insulated containers. Be sure that your aquarium is ready and waiting (full of natural sea-water) when the shipment arrives. When the specimens are delivered to you, take the temperature of the water in the shipping container and compare it with the water temperature of your aquarium. If the former is colder, let it warm up *gradually* in a warm room *before* removing any of the specimens. The temperature variation should not exceed 5° F. when the specimens are transferred. Removing living fishes or other specimens from cold water and placing them in warm water, or vice versa, will be very likely to kill them.

Aeration. Tropical marine aquaria should be aerated continually, as the animals require plenty of oxygen. This can be done at very slight cost by means of a small electric air pump and one or two air breakers.

Temperature is very important and the tropical marine aquarium must be kept quite warm. For most of the tropical forms, a temperature range of 70° to 75° F. is satisfactory. Some of the coral reef fishes seem to enjoy a water temperature of 80° to 85° F. and the snails, urchins, and starfish can stand a temperature of 60° F. But most of the tropical forms will die if the water temperature drops to much below 65° F. and as a rule the 70° to 75° range is recommended. (This is in striking contrast to the requirements of the Massachusetts Coast forms, which must be kept quite cold, and thrive best in water having a temperature of 45° to 55° F.) See our catalog listings, or write for detailed information concerning the specific temperature requirements of any of the living marine forms which we supply.

The temperature of the water in any aquarium may be kept at the desired point by means of an aquarium heater equipped with thermostatic control. A floating thermometer should also be provided so that the water temperature can be observed at any time. (When the weather is warm there is, of course, no need for a heater, but be sure that the aquarium is not allowed to cool off too much during the night.)



A very satisfactory glass terrarium. In such a container humidity is easily regulated and the tall top permits natural growth of ferns and other large plants. Note the tree frog on the glass.

THE TERRARIUM

Every biology laboratory should include in its teaching equipment not only one or more aquaria, but also several terraria in which a few terrestrial plants and animals can be maintained under approximately natural conditions. Terraria are easily started and may be maintained over long periods of time without any great amount of care.

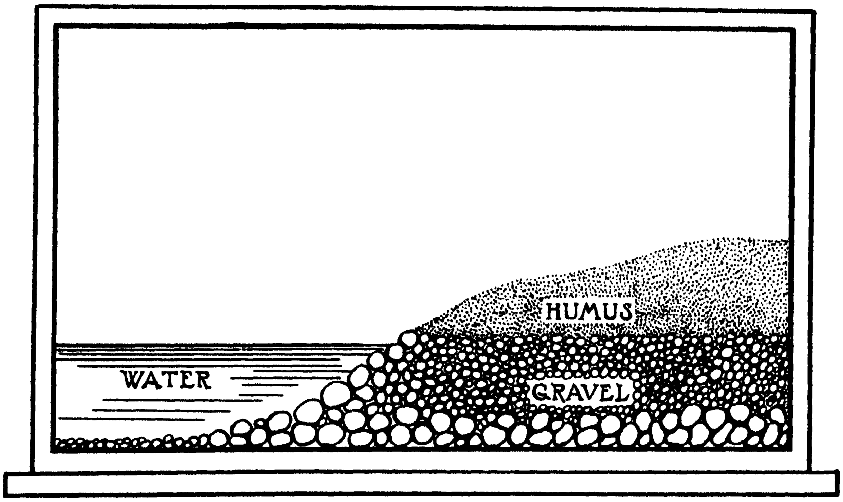
Container. After trying out a great variety of terrarium cages, we have come to the conclusion that the best container for the school terrarium is an ordinary rectangular aquarium tank, made with a frame of non-rusting metal, a slate bottom and glass sides and ends. Such tanks are made in a variety of shapes and sizes, but the very small ones should be avoided. We consider a tank of about 9-gallon capacity, measuring 18 inches long, 12 inches wide, and 12 inches high to be the smallest practical size. Larger tanks are better if a considerable number of plants and animals are to be studied.

(For small or *temporary* desert and woodland groups, the improved Turtox Miniature and Junior Vivarium Cases will prove very useful, for they offer extreme portability at very low cost.)

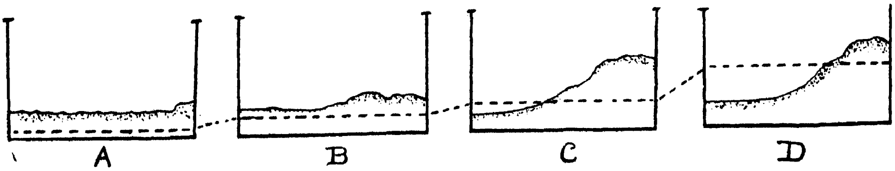
The advantages of the rectangular glass tanks are (1) that they will hold water, which is necessary in the case of bog and semi-aquatic terraria, (2) the glass sides and ends permit clear vision, (3) drafts of cold air are excluded, (4) temperature changes are slow, and (5) by the use of a glass cover humidity within the terrarium may be controlled at will. All of these factors are important and all are more or less lacking in cages made of wire screening.

In our Live Material Laboratory, we use series of 6, 9, and 12-gallon terrarium tanks for mosses, ferns, liverworts and for many of the terrarium animals. In the school laboratory, a set of four to six tanks will enable the teacher to demonstrate many living ecological groups, such as desert, dry woodland, wet woodland, bog, semi-aquatic, etc. The contents of such terraria may, of course, be varied to suit the season and teaching requirements.

Humidity. The secret of growing moisture-demanding plants in a dry and often overheated laboratory is simply a matter of controlling the humidity (moisture content) of the air. This is done very effectively by growing the plants in a glass tank such as has been described above and covering the tank with a piece of window glass cut to slightly overlap the edges. Be sure that this cover fits securely and that no large openings



Bog or Semi-aquatic Terrarium



Water Level in Terraria

The dotted line indicates the proper water level in terraria of:—A. Desert or Dry region Habitat, B. Woodland Habitat, C. Bog Habitat and D. Swamp or Semi-aquatic Habitat. The water level can be watched and kept right in terraria which are housed in rectangular glass aquarium tanks.

are left; very small cracks will take care of a sufficient circulation of air. Humidity control of this kind will enable one to keep in terrarium tanks delicate ferns, mosses, liverworts, and such animals as tree frogs, newts and land snails which would exist for only a few days in an open terrarium cage.

Such desert and dry-region forms as cacti, lizards, etc. may be kept in rectangular glass tanks which are covered with screens instead of glass plates.

Location. The terrarium should be placed where it will get plenty of light and, if possible, a little direct sunlight each day. Whether or not direct sunlight is necessary depends entirely upon the inhabitants of the terrarium. If your terrarium contains a woodland group consisting of ferns, mosses, newts, tree frogs, etc., direct sunlight will not be necessary. On the other hand, cacti, alligators, lizards, turtles, and most snakes love the sun and will not thrive unless they can live in a sunny location.

Temperature. The commoner plants and animals generally kept in terraria are not especially critical of temperature fluctuations, but one must not expect good results under impossible conditions. If the temperature of the school laboratory falls to near the freezing point over week-ends, little growth can be expected in the terrarium. Generally speaking, a daytime temperature of 75° F. and a nightly temperature of 50° to 60° F. should be about right. Tropical forms such as alligators and chameleons will require a temperature of about 80° if they are to remain active. In this connection, the only safe rule to follow is to study the plants and animals in question and to know something of their natural requirements, for an animal living in a hot, sunny climate can hardly be expected to exist long when transferred to a dark, cold terrarium.

Foundation of the Terrarium. Terrarium tanks planned to house cacti, desert lizards, horned "toads," and other forms demanding little moisture may be filled to a depth of about two inches with sand, on which are arranged several stones. Nothing more is required except a shallow pan of drinking water in one corner of the compartment.

Terraria which are planned to contain moisture-requiring plants and animals should be arranged to provide for sufficient moisture without excess. This can be accomplished by lining the bottom of the tank to a depth of about one or two inches with coarse sand or gravel. Care should be taken that this is well washed and free from all foreign material before placing it in the terrarium. This primary layer will act as a drain and will remove the excess water from the parts of the terrarium which are to be moist but not actually wet. The sand or gravel may be built up into a small mound or hill at one end of the compartment which tapers down to a lower level at the other end. Now add a layer of bog soil or woods loam about 1½ inches deep, covering the sand or gravel evenly. In or on this soil are planted the ferns, mosses, liverworts, etc. Water is now added, enough being used to completely saturate the sand and gravel layer without making the soil layer "sloppy." Pond water is best; but tap water that has been allowed to stand in an open container for several days may be used.

The directions so far will apply to almost any type of terrarium except the desert type; but, as the requirements for different habitats differ, several types of terraria will be discussed separately. The accompanying diagram on page 77 indicates by means of a dotted line the proper water level in terraria representing four distinct habitats. A school laboratory equipped with four "ecological tanks" such as these will be able to keep for study practically any of the smaller plant and animal specimens collected on field trips.

A. Desert Terrarium

This type has already been described. The lower layer of sand should be kept moist, but the surface of the sand should be dry. A pan of drinking water should be kept in one corner of the compartment, for even desert animals require water, and no dew falls in a school laboratory. Good inhabitants for the desert or dry-region terraria are horned "toads," collared lizards, snakes (from desert regions), cacti (of many kinds), and certain insects which will thrive in a dry environment. The top of the terrarium should be covered with wire screening, not with a glass plate.

B. Woodland Terrarium

Terraria of this type hold unlimited possibilities and may include many different kinds of habitats. Upon the foundation layer of sand or gravel is placed a layer of loam and decaying leaves from the woods. In this are planted ferns, mosses, liverworts, and wild flowering plants of low growth. The natural appearance of the terrarium may be heightened by one or two moss-covered stones, a dead branch covered with lichens, etc. The water level should be regulated to keep the sand layer thoroughly saturated and the loam only moist. The animal inhabitants which will thrive in such a terrarium include slugs, land snails, wood-boring beetles and other insects, tree frogs, newts (if one end of the terrarium is quite wet), wood tortoises, snakes, chameleons (*Anolis*), although not all of these would live together in harmony, in one compartment, for any length of time. The possibilities for plant groups are almost unlimited, and even many species of wild fungi may be grown successfully.

C. Bog Terrarium

The Bog Terrarium is like the Woodland Terrarium, except for two differences. It is wetter, with some water above the sand and soil at one end of the compartment, and the soil used has an acid base to comply with the requirements of the bog plants. Soil secured from a peat bog is the best; but, if this is not obtainable, soil strongly acid (test with litmus paper) will do. An acid soil is absolutely necessary, as bog plants demand this acid condition for growth. This layer of bog soil should be three or four inches deep. Sphagnum moss will grow well in such a terrarium, and the insectivorous plants such as Pitcher Plant, Sundew, and Venus Flytrap are also easily grown and are of unusual interest. These and most other insectivorous plants will thrive if planted in bog soil and sphagnum moss in a bog or semi-aquatic terrarium. Such plants should always be planted in a covered terrarium in which a fairly moist atmosphere can be maintained—never in flower pots or other open containers which subject them to the dry air of the school laboratory. Most failures with these plants are due to allowing the leaves to dry out, which will not occur in a terrarium of the type recommended.

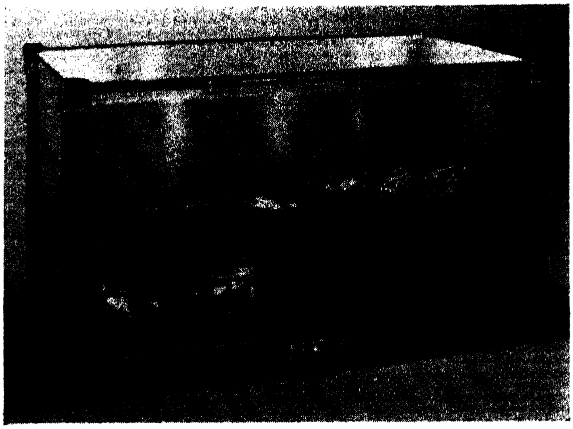
Any small animals demanding semi-aquatic surroundings will do well in a bog terrarium. Among such possibilities might be mentioned snails, newts and other salamanders, frogs, and, if one end of the terrarium contains water two or three inches deep, a few tadpoles, mud minnows and small bullheads may also be accommodated. Dragonfly larvae and other aquatic insects will prove interesting.

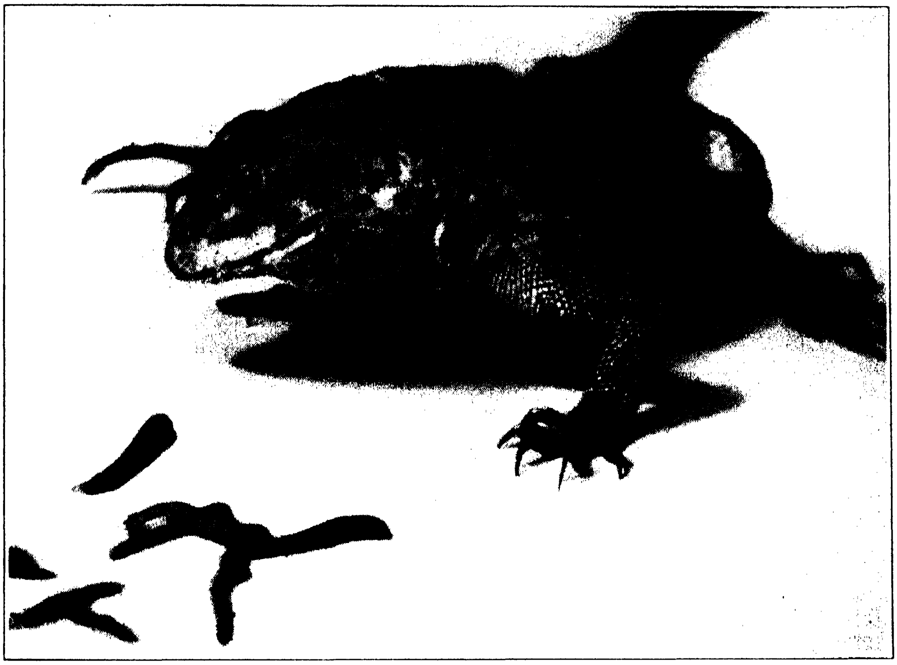
D. Swamp or Semi-aquatic Terrarium

This terrarium is very similiar to the bog terrarium, but one end is built up with rocks and bog soil to form an "island" and in the other end the water is from six to ten inches in depth. Bog or swamp plants may be grown and in a fairly large tank even the dwarf waterlilies will thrive. Truly aquatic plants such as one ordinarily places in an aquarium may be used to some extent. Practically all of the animal inhabitants of the bog terrarium may be used, as well as turtles, and a variety of such fishes as are found in swampy ponds. It must be remembered, however, that turtles are likely to devour any and all of the other terrarium inhabitants. Crayfish and the fairy shrimp will also be at home in this environment. Do not overlook the many aquatic insects, especially the mosquitoes, whose entire life cycle can be studied within a short period of time in the laboratory terrarium.

Left: A multiple aquarium and—or—terrarium unit. Some of the tanks may be used for aquaria, fresh-water and marine, and other tanks for terraria.

Right: A standard aquarium tank fitted with slate adapter to make it suitable for frogs or turtles.





A giant collared lizard feeding upon mealworms. Most reptiles require living food and react most favorably to *moving* food.

FOODS

A Word of Warning

In this booklet we have attempted to suggest suitable foods for the various laboratory animals and in every instance we have mentioned foods which we have found to be satisfactory. We have also attempted to limit our suggestions to *those foods which the average teacher can secure without too much trouble.*

It should be understood that the foods we suggest are not the only possibilities; in some instances many other foods are equally suitable. The teacher or student who is really interested in living animals will do some experimenting and he will study the special feeding requirements of the living animals he is maintaining in his laboratory cages.

There is a slight tendency on the part of those who have not become experienced in the care of living animals in the laboratory to over-feed them or to be unduly concerned about the slight amount of food required for these animals. It must be borne in mind that in most cases the laboratory specimens are kept in small areas compared with those to which the animal is accustomed in nature and that the amount of activity is reduced in proportion. With a decrease in the amount of activity there is naturally a consequent decrease in the amount of food required to sustain the animals. Do not, therefore, be alarmed if the specimen in question does not accept food each time it is offered.

Patience is an essential virtue in the care of living animals. Most of the animals described in these pages are captured from a wild state and have not been specially trained to accept laboratory food. To supply "feeders" would mean that our prices would have to be exorbitantly high. We work on the assumption that any teacher can accomplish the training required to induce the animals to take food if he or she is patient and keeps in mind the normal habits of the animal in question.

Horned toads also look with favor upon mealworms, particularly during the winter months when other living insects are not easily obtained.

Force-feeding of snakes and lizards must sometimes be resorted to. It is seldom necessary after the animals become established in a suitable terrarium.

Condensed Outline for Care of Living Specimens in the School Laboratory

This outline does not include all of the forms discussed in this book but is intended for ready reference in securing essential information regarding the most commonly used laboratory animals. For additional information on these and other forms, consult the index for page references.

ANIMAL	CONTAINER TO BE USED	TEMPERATURE RANGE OF °F	FOOD	MOST COMMON CAUSES OF FAILURE	REMARKS	DISCUSSED ON PAGE
Amoeba proteus	Finger bowl	60 to 78	Wheat or hay	Contamination, temperature changes, over feeding	Keep water in culture about 1″ deep by adding boiled pond water. Sterilize utensils and tools used	3
Chaos chaos	Finger bowl	60 to 70	Paramecium & wheat or hay	Same as Amoeba	Appear to naked eye as small tufts of cotton when they reach full size	5
Arcella	Finger bowl	55 to 75	Wheat or hay and Chilomonas		Regulate light carefully when examining culture	5
Paramecium	Finger bowl or battery jar	60 to 85	Wheat grains, rice, or timothy	Contamination and conditions encouraging growth of other protozoans	Keep in indirect light. Temp. 80° to 85° will speed development	8
Euglena	Battery jar or other deep container	60 to 90	Rice, wheat or timothy	Contamination, lack of sufficient light, pH of water	Place where culture will get plenty of light	6
Stentor	Finger bowl or battery jar	60 to 85	Mixed protozoan culture	Too much light after inoculation	Keep in diffused light after inoculation, occasionally subculture	8
Didinium	Battery jar	60 to 85	Paramecium	Shortage of food		9
Colpidium	Finger bowl or battery jar	60 to 85	Wheat grains, rice or timothy		Subculture about every three weeks	9
Blepharisma	Finger bowl	60 to 85	Wheat, rice, timothy	Food shortage	Put in diffused light, subculture every 4 weeks	9
Euplotes	Finger bowl or battery jar	60 to 85	Wheat or rice grains or timothy		Subculture about every three weeks	9
Vorticella	Finger bowls or shallow dishes	60 to 75	Wheat or hay 50% more than for Ameba	Change in water conditions	Usually found on aquatic vegetation or scum of culture water	9
Carchesium	Battery jar	50 to 70	Pond weed infusion	Too high temperature	Will also live for a long time in a balanced aquarium	10
Epistylis	Battery jars Aquaria	50 to 70	Minute algae and bacteria	Too high temperature		10
Mixed Protozoa	Battery jar	60 to 85	Wheat or timothy	One form dominating culture	Content varies greatly from time to time	10
Volvox	Battery jar, Balanced aquaria	60 to 70	Plankton	Water conditions unfavorable; too high temperature	Use pond water; place where culture will get some sunlight	8
Spongilla	Balanced aquarium	60 to 75	Ordinary material found in aquarium	Killed by too much light	Keep in shaded part of room	11
Spongilla Gemmules	Finger bowl or other shallow dish	65 to 75	Use pond water	Too much light	Transfer to balanced aquarium when well started colonies are seen in culture	12
Hydra	Balanced aquarium or jar with growing plants	60 to 70	Daphnia, cyclops or other small crustaceans	Insufficient food, sudden temperature changes	Look for specimens with sex organs in the fall	12
Planaria	Covered pan with 1½″ water	60 to 70	Fresh beef liver	Contamination by food or water not changed often enough	Be sure to change water after each feeding	15
Vinegar Eels	Natural cider vinegar	65 to 75	Get food from vinegar	Use of treated vinegar	Be sure vinegar is not mixed with artificial preservatives	16

Continued on page 84

Continued from page 83

Animal	Container to be Used	Temperature Range of °F	Food	Most Common Causes of Failure	Remarks	Discussed on Page
Earthworms	Tub or box with 18" leaves, soil, grass, sphagnum, etc.	55 to 65	Mashed potatoes, lettuce, coffee grounds	Overstocking; too much heat; too much or not enough moisture	Keep tub covered. Basement is best place for the culture	17
Earthworm Cocoons	Petri dishes lined with moist filter paper	55 to 70	Feed young worms bits of lettuce leaves	Drying out	A brownish red color indicates that cocoons are about ready to hatch; earlier stages are greenish yellow	18
Aquatic Earthworms	Aquarium with 1" of mud and 1" of sand	60 to 70	Organic matter from mud of aquarium		Keep fish out of tank as aquatic worms are excellent fish food	18
Enchytrae	Shallow box of moist loam	55 to 65	Cooked oatmeal bread soaked in milk	Souring of food	Keep glass plate on soil to prevent evaporation	18
Leeches	Balanced aquarium	60 to 70	Microscopic aquatic life	Too much light, too few plants in tank	Keep in dark place, provide stones, leaves and other hiding places in tank	19
Daphnia	Half-barrel or large 25 to 50 gal. tub	60 to 75	One ounce sheep manure to gal. water. Add lettuce leaves every 2 to 3 days	Water conditions, wrong food	Keep dark. Subculture every 6 to 8 weeks	20
Cyclops	Balanced aquarium	60 to 75	Microscopic life of aquarium			21
Gammarus	Balanced aquarium	60 to 75	Microscopic aquatic forms		Good food for large aquarium fishes	21
Brine Shrimp	Battery jar or container of quart size or larger	70 to 75	Yeast; floating Algae	Lack of food and overcrowding	Make brine solution 1% to 6%	21
Freshwater Shrimp	Balanced aquarium	50 to 60	Bits of fresh oyster, fish, beef	Insufficient vegetation	Vegetation should be thick. Will often reproduce in the laboratory	
Fairy Shrimp	Battery jars or aquarium tanks	65 to 75	Algae	No method of maintaining permanent cultures has been found. Specimens collected out of doors may be kept for several weeks		20
Crustaceans (Mixed)	Aquarium with growing plants & some dead vegetation	65 to 75	Microscopic aquatic forms	Overcrowding	Most crustaceans are eaten by fish	21
Crayfish	Semi-aquatic vivarium or balanced aquarium	65 to 75	Earthworms, fresh meat, water plants	Overcrowding, drowning	Provide rocks or other hiding places	22
Crabs Fiddler, Hermit, etc.	Semi-aquatic vivarium	65 to 75	Fresh fish, bits of fresh oysters	Overcrowding	Keep sand wet, supply plenty of food 3 or 4 times per week.	23
Centipedes	Small terrarium, battery jar or other jar with cover	60 to 70	Earthworms, slugs, soft bodied insects	Too much light without hiding places	Provide branches or rotted wood for hiding places & use leaf mold in tank	24
Millipedes	Small terrarium, battery jar or other jar with cover	60 to 70	Decaying vegetation, living roots	Drying out of terrarium	Add leaf mold or decaying vegetation occasionally	24
Scorpions	Aquarium with 1-2" of sand	65 to 80	Mealworms, spiders, insects	Too much light	Keep in dark place & food always in cage	25
Spider Cocoons	Jar or small terrarium	70 to 80	Drosophila	Too dry	Provide humidity without excessive wetness	25

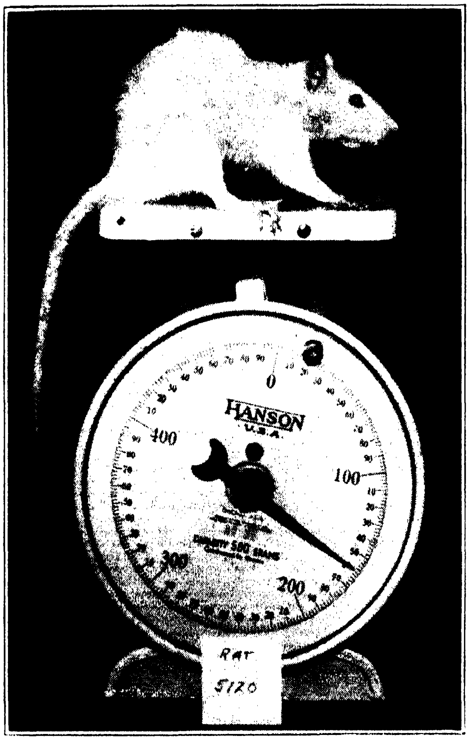
ANIMAL	CONTAINER TO BE USED	TEMPERATURE RANGE OF °F	FOOD	MOST COMMON CAUSES OF FAILURE	REMARKS	DISCUSSED ON PAGE
Walking Sticks from eggs	Screen cage or covered tank with fresh grass	70 to 80	Freshly sprouted grass	Lack of fresh, tender vegetation at hatching time	Plant lawn seed in tank so it is sprouted before eggs hatch	27
Praying mantids from eggs	Screen cage or covered tank with fresh grass	70 to 80	Fresh liver, living insects	Too much sunlight	Keep away from window or direct sunlight	26
Cockroaches	Terrarium or glass jar with 1" sawdust in it	75 to 90	Milk-soaked bread, fresh fruit, lettuce	Lack of water	Keep water available at all times in a dish, provide hiding places	27
Grasshoppers from eggs	Small terrarium or glass jar covered with screening	60 to 75	Lettuce dipped in water before feeding	Failure to keep soil moist (not wet) for eggs	Provide twigs or branches on which nymphs can climb	28
Ant Lion Larvae	Jar of fine dry sand	65 to 75	Ants, sow bugs, insects	Lack of food	Once per week is often enough for feeding but may be increased greatly	30
Tenebrio	Battery jar of 1 gal. cap. or larger covered with dark paper to keep light out	75 to 90	Bran with leaf of lettuce, a carrot or banana peel occasionally	Insufficient time for development. (Minimum of six months required for life cycle.) Lack of moisture	Cover bran with crumpled newspapers. Provide moisture in fresh vegetables	29
Moths (from cocoons)	Terrarium preferably with some green vegetation to keep humidity high	75 to 90	Adults require no food	Lack of humidity	Keep moist newspapers in cage if green growth is not available	32
Silkworms	Terrarium as above	75 to 90	Osage orange or mulberry leaves	Unsatisfactory food	Keep humidity high	31
Clothes Moths	Fine-mesh covered jar of gal. or more cap.	75 to 90	Felt wool, untreated woolcloth, dried fresh skins with fur	Too much light	Keep jar covered with dark paper	33
Butterflies from chrysalises	Screened box with 2" soil	75 to 90	Sometimes difficult to feed but sugar solutions may be tried	Insufficient ventilation, lack of humidity	Keep damp but not wet	31
Ants	Special ant home for laboratory use	75 to 85	Honey or sugar water and insects	Development of molds	Must not get too dry. Provide water as well as food regularly	34
Blowflies	Screen cage for adults, 2-qt. jar for pupation	65 to 80	Sugar; lean meat; liver	Meat drying out; lack of moisture	Larvae, adults and pupae make good food for many laboratory animals	36
Drosophila	4 oz. wide mouth bottles with cotton stoppers or milk bottles	65 to 75	Special culture media	Growth of mold on media & bacterial contamination	Sterilize all materials, tools, etc. used	37
Honey Bees	Special hive	Up to 75	Sugar or syrup water in winter	Bee moth, foul brood	May be kept and studied the year round in an observation hive	34
Bryozoans Fresh water	Balanced aquarium	Up to 75	Microscopic forms from aquarium water	Sudden changes in water conditions	A difficult form to culture in the laboratory	41
Aquatic Snails	Balanced aquarium	65 to 75	Lettuce and other green leaves	Lack of proper food, sudden temperature changes	Regular feedings of lettuce will prevent snails destroying plants	42
Land Snails	Woodland Terrarium	65 to 75	Lettuce, oatmeal	Molds, too much moisture	Allow tank to dry out thoroughly before using, then add water to moisten soil	42

Continued on page 86

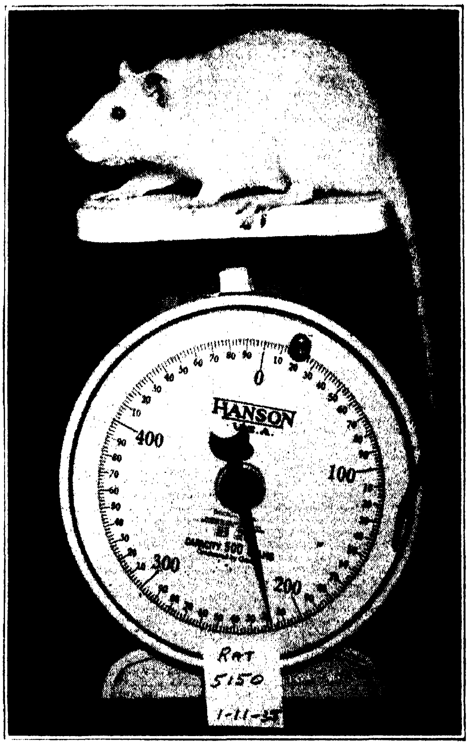
Continued from page 85

ANIMAL	CONTAINER TO BE USED	TEMPERATURE RANGE OF °F	FOOD	MOST COMMON CAUSES OF FAILURE	REMARKS	DISCUSSED ON PAGE
Clams	Bal. Aquarium or running water tank with 2-5" of sand	65 to 75	Algae, microscope aquatic life, powdered fish food	Crowding in aquarium. Change in water conditions	A gaping shell indicates a dead animal. Remove such animals promptly	44
Fishes	Bal. Aquarium	Depends upon species. Most tropicals 75° or over	Living Daphnia Cyclops, Enchytrae and prepared foods	Overstocking; contamination by excessive feeding	Be sure all food is eaten at each feeding. Keep a few snails as scavengers	46
Necturus and Cryptobranchus	Running water tank	50 to 70	Earthworms, minnows, crayfish, calf liver	Too warm water	Keep water at rather low temperature. Provide shelter from light	55
Ambystoma adults	Semi-aquatic terrarium	65 to 75	Mealworms, fresh meat	Lack of moisture	Provide small logs under which they can burrow	55
Ambystoma axolotls	Balanced Aquarium	65 to 75	Calf liver, snails, frog tadpoles	Failure to transfer to semi-aquatic group at time of metamorphosis	Cannibalistic. Provide food or large ones will devour smaller ones	54
Newts	Semi-aquatic terrarium (aquatic in aquarium)	Up to 75	Enchytrae, bits of beef, Drosophila		Must have living food or be fed by moving the food offered	54
Toads	Woodland or semi-aquatic terrarium	Up to 75	Mealworms flies, insects	Lack of moisture	Provide shelter such as leaves and branches. Do not keep with other salamanders	55
Tree Frogs	Woodland or semi-aquatic terrarium	Up to 75	Drosophila and other insects, mealworms	Lack of moisture and food	Keep humidity high	55
Grassfrogs	Semi-aquatic	Up to 75	Insects, preferably flies	Diseases such as Red leg. Over-crowding, drowning	Sterilize and thoroughly scrub tank before placing frogs in it	57
Aquatic frogs	Semi-aquatic	Up to 75	Mealworms, flies, earthworms	Too sudden temperature changes	Provide screen top to tank to give good ventilation	56
Frog eggs and tadpoles	Jar or aquarium	Up to 75	Algae, fish food, oatmeal, boiled spinach	Too sudden temperature changes, lack of sufficient oxygen in water	Provide aeration if possible	58
Terrapins	Semi-aquatic vivarium	70 to 85	Ant eggs, fish meat, tadpoles	Temperature too low or too changeable. Improper food	Provide plenty of water but means of getting out of water at will	63
Box turtles	Woodland terrarium	70 to 85	Vegetables and fruits	Failure to eat due to low temperature. Infections due to injuries	Keep water available in a shallow dish or pan	64
Alligators	Semi-aquatic vivarium	75 to 90	Raw fish and meat	Low temperatures	Keep in bright sun if possible	59
Anolis	Desert or woodland terrarium	75 to 90	Drosophila, mealworms, insects	Lack of water	Spray or sprinkle water on plants if specimen does not drink from dish or fountain	59
Collared Lizards, swifts, horned toads, etc.	Desert terrarium	75 to 90	Mealworms, flies & other insects	Failure to get water	Sprinkle plants and glass with water for animals which will not drink from dish	60
Snakes (land forms)	Woodland or desert terrarium	75 to 90	Mice, frogs, worms	Cramped quarters, excessive dryness, improper food	Provide a shelter for hiding, also rocks to climb over	61
Mice and rats	Wire cages	70 to 80	Prepared diets, table scraps	Colds caused by drafts	Keep out of cold drafts, provide sanitary cages	67
Guinea pigs	Wire cages	70 to 80	Raw vegetables and prepared foods	Sensitive to cold	Keep in warm room out of drafts, and clean the cage daily. Provide plenty of greens	66

Laboratory Experiments in Nutrition



Malnutrition due to poor protein content in diet and nutritional inbalance. Note humped back—evidence of poor calcium assimilation.



Same specimen as rat to left—after about 30 days on a complete diet. Note gain in weight, normal back curvature and generally healthful appearance.

Laboratory experiments in nutrition have great value in hygiene, domestic science and general science courses, as well as in the biology laboratory. Turtox supplies complete outfits for these experiments, furnishing the living animals, diets, cages, accessories and detailed directions for carrying out various diet, vitamin and hormone experiments.

"Laboratory Experiments in Nutrition" is a well illustrated booklet covering all phases of this work. It discusses the care of the white rat and outlines the most interesting diet and nutrition experiments. This booklet is published by the General Biological Supply House at Chicago and sells at $1.00 per copy, postpaid.

Make Use of the Turtox Service Department

The General Biological Supply House, Inc., was founded by Dr. Morris Miller Wells, who at that time was an Assistant Professor of Zoology at the University of Chicago. Since its founding the company has had a steady growth, until today its field collecting organization extends to all parts of the world and its products are used in thousands of educational institutions. This growth has been very largely due to an ideal of Service to Biology and Biologists which was worked into the very beginning of the business by its founder and which has remained its aim and purpose ever since. One result of this policy has been the building up of a staff of trained biologists, each of whom is a specialist in his own particular field. The members of this staff are not only well trained in biology, but most of them have also had experience as biology teachers; they are, therefore, well fitted to prepare material of a grade that is demanded by the modern teacher, and, what is of very real importance, they are well able to appreciate the teacher's viewpoint and to use this knowledge in a constant striving to improve materials and methods.

For many years, our Service Department has worked very closely with teachers. This department is under the direction of a former college biology professor, who devotes much of his time to answering inquiries from biology teachers. You are cordially invited to make use of this free help. We shall do our best to send you the information you request and, in instances where we cannot do this ourselves, we will attempt to put you in touch with specialists who can give you the information you desire.

Research workers in biology are invited to make use of our Research service as a means of securing rare or unusual items needed for their problems. This service is gratis and we are happy to be in a position to contribute to the advancement of biology in this way.

Much of the material for research can be obtained through our extensive collecting organization. If the material wanted is not available from the usual sources, we publish notes in Turtox News calling the attention of other biologists to the needed material. This course usually brings many responses and we are often able to locate unusual and rare specimens in this way. Write to our Research Department when you have trouble getting material for your research work.

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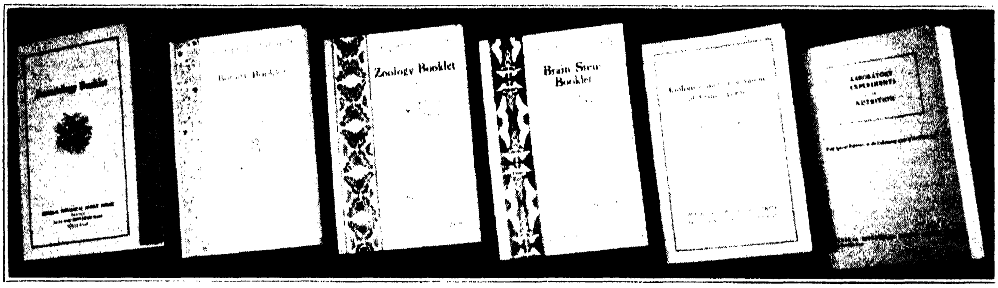
Turtox Scientific Booklets



The Turtox Booklets comprise a series of scientific pamphlets and booklets, all of which are published by the General Biological Supply House. Each booklet is written by a scientist whose training lies in the special field presented.

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TURTOX SERVICE LEAFLETS

The Turtox Service Leaflets were originally prepared primarily for the high school teacher and were written from the standpoint of secondary school science work. The letters and requests we have had for these leaflets lead us to believe that they have also proven valuable to many college and university teachers, especially in normal schools. They make excellent "outside reading" as each leaflet discusses one particular subject. A half million of these leaflets have been distributed.

The Turtox Service Leaflets are mailed on request to teachers and educational officials without charge. If desired in large quantities for distribution to students they may be purchased at 1½ cents per copy—the actual publication cost.

The leaflets listed below are now available. Since these leaflets are undergoing a more or less constant revision, we invite suggestions as to additional leaflets which would be of interest and value to biology teachers.

No. 1 How to Make an Insect Collection.
No. 2 Preserving Zoological Specimens.
No. 3 Preserving Botanical Specimens.
No. 4 The Care of Protozoan Cultures in the Laboratory.
No. 5 Starting and Maintaining a Balanced Fresh-Water Aquarium.
No. 6 Growing Fresh-Water Algae in the Laboratory.
No. 8 How to Prepare Microscope Slides of Simple Objects.
No. 9 How to Make Skeletons.
No. 10 The School Terrarium.
No. 13 Rearing the Silk Worm Moth.
No. 14 A Selected List of Books for the Biology Library.
No. 15 The Culture of Drosophila Flies and Their Use in Demonstrating Mendel's Law of Heredity.
No. 16 The Culture of Planaria and Its Use in Regeneration Experiments.
No. 19 Special Projects for Biology Students.
No. 20 Notes on Marine Aquaria.
No. 21 The Embalming and Injection of the Cat and the Laboratory Care of Embalmed Specimens.
No. 22 How to Make Laboratory Drawings.
No. 23 Feeding Aquarium and Terrarium Animals.
No. 24 Preparing and Caring for a Herbarium Collection.
No. 26 Making Biology Charts.
No. 32 The Culture and Microscopy of Molds.
No. 34 How to Maintain Living Material in the Laboratory to Demonstrate Different Types of Insect Life Cycles.
No. 35 Studying Ants in Observation Nests.
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No. 49 **Laboratory Experiments in Nutrition.**
No. 50 **Elementary Experiments in Bacteriology.**
No. 51 **Hydroponics: Growing Plants in Nutrient Solutions Without Soil.**
No. 52 Advanced Experiments in Bacteriology.

TURTOX NEWS

Turtox News is a monthly bulletin, established in 1923, and published by the staff of the General Biological Supply House. It contains notes and articles on laboratory methods, field work, microtechnique, new teaching developments, and announcements of new Turtox teaching aids.

Most of the articles appearing in Turtox News are written by members of the Turtox Staff. However, we invite teachers to contribute material they may have for publication. If you have articles or notes which you feel would be of interest to other teachers, we would be glad to have you send them to us.

Turtox News is published every month—twelve times each year—and is mailed without charge to more than thirty thousand teachers in the United States and in many foreign countries. If you are not receiving it, ask us to place your name on the mailing list.

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